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DISEASES OF WIDELY PLANTED FOREST TREES

By

SECTION 24: FOREST PROTECTION

INTERNATIONAL UNION OF FORESTRY RESEARCH ORGANIZATIONS

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WORKING GROUP ON INTERNATIONAL
COOPERATION IN FOREST DISEASE RESEARCH

Joint

FAO/IUFRO SYMPOSIUM ON INTERNATIONALLY
DANGEROUS FOREST DISEASES AND INSECTS

Oxford, 20-30 July 1964

JULY 1964

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FOREWORD

Many genera of forest trees contain one or more species that have been widely used for afforestation and reforestation. Under the new and often drastically different environments in which they are planted as exotics, they may be attacked by pathogens not previously reported on them but the principal causes of disease are usually known pathogens that are accidentally introduced or are already present in the new site. One of the most effective measures to prevent their introduction or to expedite their detection and control is to develop an awareness of potential pathogens and what may be done to reduce losses from them.

This report was drafted with that objective in mind. The scientists who wrote the different sections were requested to summarize available information on the major pathogens currently or potentially capable of causing serious losses to selected genera and species. Nine genera among the conifers (*Abies*, *Cupressus*, *Larix*, *Picea*, *Pinus*, *Pseudotsuga*, *Sequoia*, *Thuja* and *Tsuga*), six genera among the hardwoods (*Eucalyptus*, *Populus*, *Quercus*, *Robinia*, *Swietenia* and *Tectona*) and three species (*Pinus radiata*, *P. silvestris* and *Picea abies*) were selected for such treatment. All reports are combined in this volume except the one for the diseases of *Pinus radiata* which is available as a publication of the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture.

These reports have been edited only for conformity in style of presentation. The Latin names and authors of pathogens are as submitted by the individual writers. Subject matter coverage varies from exhaustive to superficial, here again reflecting the personal contributions of the writers. For additional information on any of the diseases considered, requests should be directed to the authors, whose affiliations are given in footnotes to each paper.

I wish to express my hearty appreciation to all contributors, separately and collectively, for their assistance in drafting this report. It is truly the result of cooperative effort toward a single goal - to bring together under one cover as much information as possible on the diseases of these important forest trees.

J. R. HANSBROUGH
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CONTENTS

DISEASES OF ABIES[1]

by

Ralph L. Anderson[2]

Importance of the Genus

There are about 35 to 40 species in the genus *Abies*. The firs are widely scattered through the forests of North and Central America, Europe, Asia, and Northern Africa. In southern latitudes they are usually restricted to the upper slopes of mountains, frequently including sites at or near timberline. In the boreal forests of the North Temperate and Subarctic zones firs are a major component of forest stands over extensive areas at relatively low elevations. In more northern areas however, the range of only a few species extends to the upper limits of tree growth.

In North America, Europe and Asia the firs constitute major portions of the timber volume in merchantable-size trees. They are important sources of high-quality pulp that is intensively utilized in some regions and have a high potential for exploitation in other regions that are currently relatively inaccessible. The pulp fiber quality of the firs is similar to that of the highly prized spruces. Although the lumber cut from firs does not compare in quality to that from some other softwood genera, it is widely and successfully used for this purpose. Use for lumber will undoubtedly increase substantially in the future. Firs are also a source of important oleoresins such as Canada balsam and leaf oils used in pharmaceuticals. Alpine and subalpine species generally do not have important values as a source of wood, but are of major importance in watershed protection. Some species of firs are highly prized as ornamentals and widely used for this purpose.

Ecologically, most firs are shade tolerant climax or subclimax species. They are capable of effective natural regeneration on undisturbed and shaded sites. With fire protection there is a natural trend for firs to invade areas occupied by less tolerant species and

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Lake States Forest Experiment Station, Forest Service, U.S. Department of Agriculture, St. Paul, Minnesota

to increase their population at the expense of other species. Because of the extensive areas with successful natural regeneration and consequent abundance, firs are not important plantation species in North America. In some other parts of the world where intensive forestry is practiced, they are planted rather extensively. This is particularly true in Europe and Japan.

Present and Potential Disease Impact

None of the diseases of the genus *Abies* are recognized as presenting a potential threat for catastrophic losses. The genus *Abies* is, however, host to a very large number of diseases, several of which have demonstrated that they can and do cause serious damage.

The wood of fir trees is highly susceptible to decay, both in the living trees and products. As a consequence, fir is subject to serious heart rot losses caused by several kinds of fungi. The impact of heart rot on firs is greater than that of all other diseases combined. Also, firs are more subject to serious decay losses than are most genera of conifers.

Although there is an extensive literature on the diseases of *Abies*, detailed attention has been given to a relatively small proportion of the pathogens. For many there is little information other than apparent pathogenic occurrence on *Abies* in some locality. For most of the diseases there is no sound basis for assessing their potential on exotic hosts or in new environments. In the specific records that follow an attempt has been made to list all organisms that have shown some evidence of definite pathogenicity on *Abies* or for which this possibility cannot be excluded on the basis of available information. Organisms reported on *Abies* for which all evidence suggests that they are saprophytes have been omitted. Comments on specific diseases are included only for those diseases that appear to be particularly important and also either unique to *Abies* or more important on this genus. Some diseases that are regarded as important on *Abies* are considered to be even more important on other genera of conifers. In the interest of brevity these are listed but not discussed in detail.

SEEDLING DISEASES

Organisms capable of damaging nursery seedlings must be considered important where climatic and edaphic factors are favorable for their development. Most of the organisms that attack *Abies* seedlings have a broad host range including other genera of conifers and, in some cases, also hardwoods. Good nursery practices, seed treatment and soil fumigation can materially reduce losses.

Causal organism and type of damage	Reported from:
Agrocybe tuberosa (Henn.) Singer Pre-emergence damping-off	Japan
Botrytis cinerea Fr. Graymold blight Causes blight and decay of young seedlings.	Argentina, China, Europe, Japan, USA

Commonly saprophytic, but occasionally pathogenic, and can inflict serious damage. It is favored by high air moisture, and forms a dense gray mold on blighted plant parts in moist situations. Abundant conidia are airborne for unknown distances. Older trees may be infected at injuries. Any measure to improve air circulation will reduce damage.

Botrytis sp. Seedling twig-blight	USA
Cucurbitaria pithyophila (Fr.) de N. Seedling mortality	Europe, Japan, USA
Fusarium bulbigenum var. *blasticola* (Rostr.) Wr. Damping-off	Argentina, North America, Europe
Fusarium oxysporum Schlecht. var. *aurantiacum* (Lk.) Wr. Damping-off	Europe, Japan, USA
Fusoma parasiticum Tub. Damping-off	Europe, USA
Helicobasidium purpureum (Tul.) Pat. Root rot	Africa, Asia, Australia, Europe, North and South America
Herpotrichia nigra Hartig Conifer brown felt blight	Europe, North America, Siberia
Pellicularia filamentosa (Pat.) Rogers Web blight	Africa, Asia, Australia, Europe, North and South America
Pestalotia hartigii Tub. Stem girdle	Europe, USA, possibly South Africa
Phacidium abietinellum Dearn. Needle blight	North America

Phacidium balsameae Davis Needle blight	USA
Phacidium infestans Karst. Conifer snow blight	Canada, Eastern USA, Europe north of 60° Lat.
Phacidium infestans var. abietis Dearn. Conifer snow blight	USA
Phytophthora cactorum (Leb. & Cohn) Schroet. Seedling blight	Africa, Europe, eastern Asia, North and South America
Phytophthora cinnamomi Rands Root rot	USA
Pythium debaryanum Hesse Root rot	Asia, Canada, Europe, Hawaii, USA
Rhacodium terryanum Theum. Snow blight of seedlings	Japan
Rhizina undulata Fr. (R. inflata (Schaeff.) Sacc.) Root rot	Europe, North America
Rhizoctonia solani Kuehn Damping-off	Japan (much broader distribution on other hosts)
Thelephora terrestris Fr. Smothering fungus	Europe, North America, South Africa

ROOT DISEASES

Root diseases have great potential importance, especially in plantations. Extensive controls are generally impractical. Planting only disease-free stock may reduce losses in some cases. Many of the organisms that cause root rot on Abies have a wide host range including other genera of conifers and hardwoods. Unless otherwise indicated, the following fungi cause root rots of fir trees of all ages.

Causal organism and type of damage	Reported from:
Agrobacterium tumefaciens (E.F. Sm.& Town.) Conn Crown gall	Practically worldwide
Armillaria mellea (Fr.) Quél.	Practically worldwide

Corticium odoratum (Fr.) Bourd. & Galz.	Czechoslovakia, Sweden
Corticium radiosum Fr.	Western USA
Fomes annosus (Fr.) Karst.	Australia, North Temperate Zone
Polyporus dryadeus Fr.	Asia, Australia, Europe, North America
Polyporus hirtus Quél.	USA
Polyporus schweinitzii Fr.	Australia, North Temperate Zone
Polyporus tomentosus Fr. (including var. circinatus (Fr.) Sartory & Maire)	Canada, Europe, India, USA
Poria aurea Peck	USA
Poria colorea Englerth	Western USA
Poria weirii Murr.	Alaska, Canada, Japan, USA
Pythium torulosum Coker & Patterson	Europe, USA

STEM DISEASES

Stem diseases are important in the genus Abies. Some cankers have a serious potential but in general no control measures are practical. The mistletoes cause serious damage in some areas, and the most feasible control is eradication. The firs are notoriously susceptible to heart rot caused by many fungi. The best control for these diseases is to harvest before losses are excessive.

Cankers

Causal organism and type of damage	Reported from:
Aleurodiscus amorphus (Fr.) Rab.	Europe, North America Siberia
Bothrodiscus pinicola Shear	Canada
Caliciopsis pinea Pk.	Germany, USA

Cephalosporium sp.	USA
Cryptosporium macrospermum Pk.	Eastern USA
Dasyscyphus abieticolus Henn. & Shirai (Trichoscyphella calycina Schum. ex Fr.)	Japan
Dasyscyphus calyciformis (Willd.) Rehm	Europe, Japan, New Zealand, North America, Siberia
Dasyscyphus resinarius (Cke. & Phill.) Rehm	Norway, USA
Dasyscyphus subtilissimus (Cke.) Sacc.	Northern Europe, northeastern USA
Diplodia pinea (Desm.) Kickx Also causes twig blight	Worldwide, but notably in New Zealand and South Africa
Fusicoccum abietinum Prill. & Delacr. Also causes red flag of balsam fir	Eastern Canada
Ophionectria scolecospora Bref.	Eastern USA
Pezicula livida (Berk. & Br.) Rehm	Eastern North America, Europe
Pleurotus mitis (Fr.) Quél.	Europe, North America
Phacidiopycnis pseudotsugae (M. Wils.) Hahn (Phomopsis pseudotsugae Wilson) (P. strobi Syd.) Potentially very important	New Zealand, Northeastern USA, western Europe
Phoma abietina Hartig	Western USA
Phomopsis abietina (Hartig) Wilson & Hahn	Europe
Phomopsis boycei Hahn	USA
Phomopsis montanensis Hahn	Western USA
Retinocyclus abietis (Crovan) Grove & Wells	Western Canada
Scleroderris abieticola Zeller & Goodding	Western USA

Septobasidium kameii K. Ito Septobasidium disease	Japan
Trichosporium symbioticum Wright Brown sapwood stain	USA
Valsa kunzei Fr. var. kunzei (Typical) (Cytospora kunzei Sacc., imp. stage)	Europe, North America

Diebacks

Diseases of the genus Abies that are referred to as diebacks are generally caused by fungi whose mode of action is difficult to distinguish from those referred to as canker diseases. None of the dieback diseases is caused by fungi of the vascular wilt type.

Causal organism and type of damage	Reported from:
Cenangium atropurpureum Cash & Davidson	Canada
Cenangium ferruginosum Fr. (formerly confused with Cenangium abietis (Fr.) Rehm.)	Europe, North America
Cytospora friesii Sacc.	Canada
Dermea balsamea (Pk.) Seav.	Canada

This fungus plus Thyronectria balsamea (Cke. & Pk.) Seel. and Valsa abietis Fr. have been associated with what is regarded as a serious dieback and mortality in Canada. The disease has been studied only during the past decade, and although its long-term potential is unknown, the serious damage caused during the mid 1950's requires that it be considered potentially dangerous.

Diaporthe conorum (Desm.) Niessl (Phomopsis occulta Trav.) Dieback and canker.	Japan, Western North America

Although this fungus is considered to be a saprophyte in North America, it is reportedly causing serious damage to young plantations in Hokkaido. The damage is associated with frost injury.

Micropera abietis Rostr.	USA
Nectria cucurbitula Fr.	Europe, North America
Spicaria anomala (Corda) Harz Brown stain of sapwood	USA
Thyronectria balsamea (Cke. and Pk.) Seeler. (See comments under Dermea balsamea)	Canada
Valsa abietis Fr. (See comments under Dermea balsamea)	Canada

This fungus is usually present in its imperfect stage, Cytospora abietis Sacc.

Bark rusts

Causal organism and type of damage	Reported from:
Chrysomyxa woronini Tranz. Spruce stunted-shoot rust	India, Japan, Kamchatka, northern Europe, northern North America, Siberia
Melampsorella caryophyllacearum Schroet. (M. cerastii (Pers.) Schroet.) Fir witches'-broom.	Asia, Europe, North America

This is the most serious rust of firs. The witches' brooms, swellings, and cankerlike lesions it causes are responsible for considerable damage and cull, particularly in Europe. The only practical control is early removal of trees with stem infections and pruning to reduce prevalence of such infections.

Heart Rots

Causal organism and type of damage	Reported from:
Coniophora olivacea (Fr.) Karst. Butt rot	Europe, North America, Northern Asia
Coniophora puteana (Fr.) Karst. (C. cerebella Pers.) Butt rot	Europe, North America, Siberia, South Africa

Corticium galactinum (Fr.) Burt Stringy white butt rot	Czechoslovakia, Finland, Japan, Poland, North America, Siberia, West Indies
Echinodontium tinctorium E. & E. Brown stringy heart rot	Western North America

This fungus is one of the most serious causes of heart rot of firs in western North America. Losses of 25 percent or more of gross volume are not uncommon. Infection occurs through branch stubs and wounds.

Fomes nigrolimitatus (Rom.) Egeland (_F. putearius_ Weir) Heart rot	China, Japan, New Zealand, northern Europe, western North America
Fomes officinalis (Fr.) Faull Heart rot	China, Europe, Japan, North Africa, northern North America, Sakhalin Island, Siberia
Fomes pini (Fr.) Karst. Heart rot	Throughout temperate coniferous forests of Northern Hemisphere
Fomes pinicola (Fr.) Cke. Wound rot	Throughout North Temperate Zone
Fomes robustus Karst. (_Phellinus hartigii_ (Sacc. et Schnabl) Imazeki) (_Poria tsugina_ (Murr.) Sacc. & Trott.) (_Fomes hartigi_ (Allesch) Sacc.) (_Polyporus hartigi_ Allesch.) White heart rot	Australia, Europe, Japan, New Zealand, North America, Siberia, South Africa
Hydnum abietis Hubert Heart rot	Western North America
Hydnum cirrhatum Fr. Trunk rot	Europe, North America
Hydnum coralloides Scop. ex Fr. Heart rot	USA
Odontia bicolor (A. & S.) Bres. Stringy white butt rot	Western North America

Oxyporus nobilissimus W. B. Cooke Butt rot	USA
Pholiota adiposa (Fr.) Quél. Trunk rot	Europe, Japan, New Zealand, North America
Pholiota aurivella (Fr.) Quél. Heart rot	Europe, India, North America
Pholiota flammans Fr. Heart rot	Western North America
Pholiota squarrosa (Mull.) Fr. Butt rot?	Western USA
Polyporus balsameus Pk. Butt rot	Japan, northern North America, Sweden
Polyporus berkeleyi Fr. Butt rot	Australia, India, New Zealand, North America, Phillipines, Russia
Polyporus borealis Fr. Heart rot	Japan, western North America
Polyporus circinatus Fr. White pocket rot	Northeastern USA
Polyporus guttulatus Pk.	Japan, northeastern USA
Polyporus sulphureus Fr. Trunk rot	Australia, Europe, India, Japan, North America, Philippines, Siberia
Poria subacida (Pk.) Sacc. Butt rot	Costa Rica, Japan, North America
Poria vaporaria (Fr.) Cke. Trunk rot	Australia, Europe, Japan, North & South America, Siberia
Sparassis crispa (Wulf) Fr. Trunk rot	Japan
Stereum abietinum (Fr.) Fr. Brown cubical rot	Europe, Japan, North America
Stereum chailletii Pers. ex Fr.	Western USA

Stereum sanguinolentum Fr. — Australia, Europe, Japan, New Zealand, North America, Siberia, South Africa

This fungus causes a very serious heart rot of *Abies balsamea* (L.) Mill. Infection is through broken tops, branch stubs, and other wounds.

Trametes insularis Murrill — Japan
Trunk rot

Mistletoes and Dwarfmistletoes

Causal organism and type of damage	Reported from:
Arceuthobium campylopodum Engelm. f. (*abietinum* (Engelm.) Gill) Dwarfmistletoe or witches'-broom	Western USA
Phoradendron bolleanum (Seem.) Eichler var. (*Pauciflorum* (Torr.) Fosberg) (*P. pauciflorum* Torr.) Mistletoe	Mexico (Baja California) USA
Viscum album L. European mistletoe	Czechoslovakia, France, Germany, Poland

FOLIAGE DISEASES

Although some foliage diseases of firs can cause serious damage, the great majority are usually of minor importance, such as the 70 some species of needle rusts in the three genera *Hyalopsora*, *Milesia*, and *Uredinopsis*. Direct controls are generally not feasible for forest trees.

Blights

Causal organism and type of damage	Reported from:
Acanthostigma parasiticum (Hartig) Sacc.	Denmark, Germany, Great Britain, Nova Scotia, Switzerland

This disease has demonstrated a serious potential in Denmark. Under moist air conditions it has killed and badly damaged fir trees. The disease is characterized by the dead needles being held on the twigs by mycelial threads.

Cytospora pinastri Fr.	Europe, USA
Herpotrichia nigra Hart. Brown felt blight	Europe, North America
Herpotrichia quinqueseptata Weir	Western USA
Macrophoma parca (Berk. & Br.) Berl & Vogl.	Western USA
Macrophoma pinsaponis Neger	Spain
Rehmiellopsis abietis (E. Rostr.) O. Rostr. (R. bohemica Bub. & Kab.) Fir tip blight of newly formed needles.	Canada (once in British Columbia), northern Europe

In severe attacks most of new needles are killed and the shoots die back. Repeated attacks can kill trees. The disease appears to be most severe on poor sites. A late, moist growing season increases susceptibility to infection. Early symptoms are yellow-pink spots on new needle tissue uncovered by loosening bud scales. Affected shoots die, and needles change color from light green to yellowish-pink, then reddish-brown, and finally to gray. Small black fruiting bodies form on the upper surface of the needles about 6 weeks after first evidence of the disease.

Rehmiellopsis balsameae Waterman	Eastern Canada, northeastern USA

An important disease essentially identical to that described above except for species of the fungus and its geographical distribution.

Rhabdogloeum abietinum Dearn.	USA
Rosellinia herpotrichioides Hepting & Davidson Needle and twig molding	Canada (British Columbia), Japan, USA

Needle casts

Causal organism and type of damage	Reported from:
Bifusella abietis Dearn.	USA
Bifusella faullii Darker	Eastern North America

<u>Hypoderma</u> <u>robustum</u> Tub. (<u>Lophodermium</u> <u>infestans</u> Mayer)	Western North America, Germany
<u>Hypodermella</u> <u>abietis-concoloris</u> (Mayr) Dearn.	Western North America
<u>Hypodermella</u> <u>lirelliformis</u> Darker	Austria, Germany
<u>Hypodermella</u> <u>macrospora</u> Lagerberg	Western USA
<u>Hypodermella</u> <u>mirabilis</u> Darker	Eastern USA
<u>Hypodermella</u> <u>nervata</u> Darker	Eastern USA
<u>Hypodermella</u> <u>nervisequia</u> (Fr.) Lager	China, Japan, Europe
<u>Hypodermella</u> <u>punctata</u> Darker	USA
<u>Lophodermium</u> <u>decorum</u> Darker	USA
<u>Lophodermium</u> <u>lacerum</u> Darker	Northeastern USA
<u>Lophodermium</u> <u>nervisequum</u> D.C.	Japan
<u>Lophodermium</u> <u>piceae</u> (Fckl.) Hoehn	India, Europe, North America
<u>Lophodermium</u> <u>pinastri</u> (Fr.) Chev.	Western USA
<u>Lophodermium</u> <u>uncinatum</u> Darker	USA
<u>Phaecryptopus</u> <u>nudus</u> (Pk.) Petr. (<u>Adelopus</u> <u>nudus</u> (Pk.) Hoehn.) Reported as causing severe damage to plantations in Japan	Europe, Japan, North America, Siberia
<u>Rhizosphaera</u> <u>pini</u> (Cda.) Maubl.	USA
<u>Trichosphaeria</u> <u>parasitica</u> Hart.	Quebec

<u>Needle rusts</u>

<u>Causal organism and type of damage</u>	<u>Reported from:</u>
<u>Caeoma</u> <u>faulliana</u> Hunter	Western USA
<u>Calyptospora</u> <u>goeppertiana</u> Kuhn	Japan, Korea, North America

Chrysomyxa ledi var. rhododendri (D C.) Savile	China, Europe, Japan, Siberia. In North America found only on rhododendron, the alternate host.
Hyalopsora aculeata Kamei	Japan
Hyalopsora aspidiotus Magn.	Europe, Japan, Kamchatka, North America
Melampsora abieti-capraearum Tub. Fir-willow rust	North & South America, western Europe
Melampsora abietis-populi Imai	Japan
Melampsora albertensis Arth.	Western USA
Melampsora epitea Thuem.	Europe, India, Japan, Kamchatka, North & South America
Milesia blechni (Syd.) Syd.	Europe
Milesia fructuosa Faull	Eastern North America
Milesia itoana (Kamei) Faull	Japan
Milesia jezoensis (Kamei & Hirat.) Faull	Japan
Milesia kriegeriana (Magn.) Arth.	Europe
Milesia marginalis Faull & Watson	Northeastern USA
Milesia polypodii B. White	Europe
Milesia polypodophila (Bell) Faull	Northeastern USA
Milesia scolopendrii (Fckl.) Arth.	Europe
Milesia vogesiaca (Syd.) Faull	Algeria, Europe, Japan, western North America
Milesina dryopteridis Kamei	Japan
Milesina exigua Faull	Formosa, Japan, Korea
Milesina miyabei Kamei	Formosa, Japan

Maemacyclus niveus (Fr.) Sacc.	North and central Africa, North America, western Europe
Peridermium balsameum Pk.	Canada
Peridermium holwayi Syd.	Western USA
Peridermium ornamentale Arth.	Western USA
Peridermium rugosum Jacks.	Western USA
Pucciniastrum abieti-chamaenerii Kleb.	North America
Pucciniastrum epilobii Otth	Europe, Japan, New Zealand, North America, Siberia
Pucciniastrum goeppertianum (Kuehn) Kleb.	North Temperate Zone
Pucciniastrum kusanoi Dietel	Japan
Pucciniastrum miyabeanum Hiratsuka	Japan
Pucciniastrum pustulatum (Pers.) Diet.	USA
Pucciniastrum stylacinum Hiratsuka	Formosa, Japan
Pucciniastrum tiliae Miyabe	China, Japan
Uredinopsis adianti Komarov	Japan, Manchuria
Uredinopsis athyrii Kamei	Japan
Uredinopsis atkinsonii Magn.	Eastern USA
Uredinopsis ceratophora Faull	Eastern North America
Uredinopsis copelandi Syd.	Western USA
Uredinopsis filicina (Niessl) Magnus	Europe, Japan, Siberia
Uredinopsis hashiokai Hirats. f.	Canada
Uredinopsis hirosakiensis Kamei & Hiratsuka	Japan, Siberia
Uredinopsis intermedia Kamei	Japan, Vladivostok
Uredinopsis kameiana Faull	China, Japan, Siberia

Uredinopsis longimucronata Faull	Western North America
Uredinopsis macrosperma (Cooke) Magn.	Western USA
Uredinopsis mirabilis (Peck) Magn.	Eastern North America
Uredinopsis ossaeiformis Kamei	Japan, Korea, Siberia
Uredinopsis phegopteridis Arth.	USA
Uredinopsis osmundae Magn.	Eastern North America
Uredinopsis pteridis Diet. & Holw.	Canada, China, Japan, Korea
Uredinopsis struthiopteridis Störmer ex Diet.	Europe, Japan, North America, Siberia
Uredinopsis woodsiae Kamei	Japan

CONE DISEASES

Only one disease of fir cones has been reported and losses from it are negligible.

Causal organism and type of damage	Reported from:
Sclerotinia kerneri Wettstein Twig thickening and staminate cone proliferation	North America

SYSTEMIC DISEASES

No diseases of *Abies* are recognized that can be regarded as truly systemic. The following disease, however, is more closely related to vascular wilts than any of the other categories used in this report.

Causal organism and type of damage	Reported from:
Ceratocystis piceae (Münch) Bakshi Blue stain of living sapwood	Europe, Japan, USA

DISEASES OF CUPRESSUS[1]

by

Willis W. Wagener[2]

The cypresses of the genus *Cupressus* have persisted in the temperate regions of the world from ancient times. In places the native ranges of several species extend into the tropics but only in the highlands. Rarely, if ever, within historic times have the cypresses formed a continuous forest. Instead the native stands almost invariably consist of small and often isolated groves on slopes, ridge tops or headlands, very often rocky and invariably well drained. Other characteristics of their natural environments are well marked dry periods and full insolation.

Botanists differ in their interpretations both of the genus and species limits. Some include *Chamaecyparis* as a section of the genus but the general practice in America is to limit the genus to the members of the section *Eu-cupressus* and to regard *Chamaecyparis* as constituting a separate genus. This more limited genus concept is followed in the present paper.

By a broad inclusive interpretation of species within the genus, there are about 11 in the world, of which 7 are native to North America and 4 to the Mediterranean region and southern Asia. By a more restricted interpretation 15 species are credited to North America, of which 10 are limited to California.

Among the most important species, with their natural ranges, are:

(1) *Cupressus arizonica* Greene. Arizona cypress
Southwestern U.S.A. and northern Mexico

(2) *Cupressus lusitanica* Mill. Mexican cypress
Highlands of Mexico and Guatemala

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

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(3) Cupressus macrocarpa Hartw. Monterey cypress
Central coast of California (U.S.A.)

(4) Cupressus sempervirens Endl. Italian cypress
Mountains of Asia Minor and the Mediterranean islands of Rhodes, Crete and Cyprus

Importance of the Group

The cypresses have been widely planted as shade, ornamental and windbreak trees in many parts of the warmer temperate regions of the world and as forest trees in the highlands of Guatemala, Kenya, and Tanganyika. Smaller forest plantings, mostly on a trial basis, have been made elsewhere. Arizona cypress has gained considerable favor as a Christmas tree species in some parts of the southern United States of America and is planted there for that purpose. A disadvantage of the cypresses as timber trees is the persistence of side branches, making pruning a necessity to obtain clear trunks.

This characteristic tends to limit their culture for forestry purposes to countries where labor for pruning is available at rates that are not prohibitive.

The wood of cypresses has very desirable technical qualities, including fine grain, a uniform texture, a pleasing fragrance and high durability. The doors of St. Peters in Rome were constructed of the wood of Italian cypress and were still sound when replaced after 11 centuries of service. Where locally available the wood is highly regarded for construction purposes.

Present and Potential Disease Impact

Because of their restricted native habitats and the natural protection against diseases often afforded by the environmental conditions of these habitats, cypresses are likely to be more susceptible to disease when transplanted to sites where this protection is lacking than more ubiquitous tree genera. Thus during the last 35 years, cypress canker has destroyed countless thousands of Monterey cypresses planted inland from the immediate coast in California but has not appeared in the two native groves protected by cool winds from the adjacent Pacific Ocean.

Moreover, in trials of cypress species in various parts of the world they have been introduced at many locations with climates to which they are incompatable, resulting in diseases absent in their natural habitats. Among the fungi reported as disease organisms on cypresses but which are primarily indicators of climatic incompatibility of the

hosts to the sites to which they have been introduced are: Botrytis cinerea, Cercospora thujina, Corticium salmonicolor, Cytospora cenisia f. littoralis, Pestalotia funerea and Phomopsis juniperovora.

The most serious disease of cypresses is the cypress canker induced by the closely related fungi Rhynchosphaeria cupressi Nattrass, Booth and Sutton, (imperfect stage, Monochaetia sp., commonly reported as M. unicornis (Cke. and Ell.) Sacc.) and Coryneum cardinale Wagener. Determination of the actual relationship of these forms must await a comparative study of the Rhynchosphaeria with the undescribed perfect stage of Coryneum cardinale, reported as a Leptosphaeria. The pathologic effects of attack by these fungi are so similar that for practical purposes the reactions can be regarded as constituting a single disease. Cankers are formed on twigs, branches, and main stems, usually accompanied by resin exudation and by the resin infiltration of dying bark tissues. Rapidly growing, open-crowned trees are more susceptible than slow growing or hedged specimens. Cupressus macrocarpa has proven to be the most susceptible of the Cupressus species exposed to the disease, but all species of the genus seem to be susceptible to some degree, particularly where young, rapidly-growing trees are located where canker incidence in the immediate surroundings is high. Because of the general high susceptibility of Cupressus macrocarpa to the disease, planting of this species has been discontinued in a number of areas where it was formerly popular because of its other desirable characters.

There is no certainty as to the origin of cypress canker in most of the countries in which it has appeared. Importation of the inciting fungus may well have been the source in some countries but indications are growing that in others the canker fungus may already have been present in an inconspicuous form on another host when the cypresses were introduced or their ranges extended by planting. This could have been the case with Rhynchosphaeria cupressi in East Africa, where a Monochaetia has been found on the native Juniperus procera, and with Coryneum cardinale in California, where a Coryneum occurs on the indigenous Sequoia sempervirens. Once established on cypresses, however, the causal fungi can readily be disseminated on nursery stock, or on infected materials such as fuel wood cut from diseased trees.

The following list of organisms reported as causing diseases on Cupressus is an inclusive one, in which no allowance has been made for the conditions under which infection occurred. Thus it includes fungi already mentioned as examples or organisms that have been favored because of environments to which the host trees were not compatable. It also undoubtedly includes a number of organisms that are of very minor significance as pathogens of cypresses, as

well as those that are important. Most of the organisms listed are from host species that have been rather widely planted and thus have had a broader opportunity for exposure to disease organisms than those not in cultivation or that have been planted outside of their native habitats only to a limited degree. Thus the list has little significance as an indicator of the true status of a cypress species with respect to disease susceptibility.

SEEDLING DISEASES

Because the native habitats of cypresses do not favor the development of seedling diseases, these diseases can be expected to be troublesome when the seedlings are grown under usual nursery conditions. To minimize the chances for attack by disease organisms in the nursery, cypress seedlings should be given plenty of room, air movement over the beds should not be restricted, and watering should be kept to a minimum and carefully regulated. For root diseases, prior fumigation of the soil or drenching of it with an effective fungicidal solution may be necessary in advance of planting.

Causal organism and type of damage	Hosts, and from where reported:
Botrytis cineria Pers. ex Fr. Graymold blight	*C. macrocarpa* Gt. Brit., New Zealand *C. sempervirens* Gt. Brit.
Fusarium bulbiginum var. *blasticola* (Rostr.) Wr. Damping-off	*C.* sp. Argentina
Fusarium solani (Mart.) Appel. & Wr. Seedling root rot	*C. sempervirens* U.S.A.
Macrophomina phaseoli (Maubl.) Ashby	*C. lusitanica* Uganda
Phomopsis juniperovora Hahn Cedar blight	*C. arizonica* U.S.A. *C. duclouxiana* U.S.A. *C. goveniana* U.S.A. *C. lusitanica* U.S.A. *C. macrocarpa* New Zealand, U.S.A. *C. sempervirens* U.S.A.

Phomopsis juniperovora induces a blight both on seedlings and on somewhat older trees in plantations and other plantings. It is common in the eastern half of the U.S.A. Various strains occur, some of which are host specific or are restricted to a particular group of hosts.

Phomopsis occulta (Sacc.) Trav.	*C. sempervirens* Italy
Pythium ultimum Trow. Seedling root rot	*C. lusitanica* New Zealand *Cupressus* sp. Rhodesia

ROOT DISEASES

Causal organism and type of damage	Hosts, and from where reported:
Agrobacterium tumefaciens (E. F. Sm. & Town.) Conn Crown gall	*C. duclouxiana* U.S.A. *C. lusitanica* U.S.A. *C. sempervirens* U.S.A.
Armillaria mellea (Fr.) Quél. Shoestring root rot	*C. guadalupensis* U.S.A. *C. lusitanica* Tanganyika *C. macrocarpa* Kenya, New Zealand, U.S.A. *Cupressus* spp. Kenya
Armillaria tabescens (Scop. ex Fr.) Emel. Clitocybe root rot	*C. sempervirens* U.S.A.
Phymatotrichum omnivorum (Shear) Dug. Texas root rot	*C. arizonica* U.S.A. *C. sempervirens* U.S.A.
Phytophthora cactorum (Leb. & Cohn) Schrot. Rootlet rot	*C. macrocarpa* New Zealand
Phytophthora cinnamomi Rands Root rot	*C. macrocarpa* New Zealand *C. sempervirens* U.S.A. *Cupressus* sp. Argentina

The presence of this fungus on cypresses indicates that the hosts have been planted in soils that are not sufficiently well drained. This observation probably applies also to the next fungus listed.

Pythium polymorphon Sideris Root rot	*C. sempervirens* Argentina
Rhizoctonia lamellifera Small	*Cupressus* sp. Uganda

STEM DISEASES

Cankers

Causal organism and type of damage	Hosts, and from where reported:
Coryneum berckmanii Milbrath Coryneum blight	*C. sempervirens* U.S.A.
Coryneum cardinale Wagener Cypress canker	*C. arizonica* Italy, U.S.A. *C. bakeri* U.S.A. *C. goveniana* U.S.A. *C. guadalupensis* U.S.A. *C. lusitanica* Italy, U.S.A. *C. macnabiana* U.S.A. *C. macrocarpa* Argentina, France, Italy, New Zealand, Spain, U.S.A. *C. sempervirens* Italy, Spain, U.S.A.
Corticium salmonicolor Berk. & Br. Pink disease	*C. macrocarpa* Kenya
Cytospora cenisia Sacc. f. *littoralis* Zent.	*C. arizonica* U.S.A. *C. macrocarpa* U.S.A. *C. sempervirens* U.S.A.
Diplodia natalensis Pole-Evans Collar rot	*C. sempervirens* Israel
Diplodia pinea (Desm.) Kicks	*C. sempervirens* Australia *Cupressus* sp. Congo
Gymnosporangium cunninghamianum Barcl. Cypress rust	*C. duclouxiana* China, India Pakistan
Gymnosporangium cupressi Long & Goodding Gall rust	*C. arizonica* U.S.A.
Gymnosporangium distortum Arth.& Cumm. Cypress rust	*C. duclouxiana* India
Gymnosporangium meridissimum Crowell Gall rust on twigs	*C. lusitanica* Guatemala
Gymnosporangium minus Crowell Rust on twigs and stems	*C. sempervirens* Greece

Gymnosporangium tsingchenensis Wei Rust on branches and trunks	C. duclouxiana China
Monochaetia sp.	C. sempervirens U.S.A.
Pestalotia funera Desm.	C. arizonica U.S.A. C. lusitanica New Zealand, South Africa C. macrocarpa New Zealand C. sempervirens India, U.S.A.
Rhynchosphaeria cupressi Nattrass, Booth & Sutton (Monochaetia sp., reported as M. unicornia) Cypress canker	C. arizonica New Zealand, Tanganyika C. duclouxiana New Zealand, Tanganyika C. lusitanica New Zealand, Tanganyika C. macrocarpa Australia, Kenya, New Zealand, Tanganyika C. sempervirens New Zealand Cupressus sp. Australia

Heart rots

As might be expected from the character of their wood, cypresses are relatively free of heart rots or other decays. However, the heart rots in native stands have not been thoroughly investigated. At least one is known to be quite common in some stands of native C. arizonica but no associated sporophores have been found and the identity of the inciting fungus has not been determined.

Causal organism and type of damage	Hosts, and from where reported:
Hymenochaete mougeotii (Fr.) Cke. Butt rot	C. lusitanica Australia
Polyporus basilaris Overh. Heart rot	C. macrocarpa U.S.A.
Polyporus cutifractus Murr.	C. macrocarpa U.S.A.
Stereum purpureum (Fr.) Fr. White mottled rot	C. macrocarpa New Zealand
Trametes trogii Berk. White rot	C. sempervirens Argentina

Mistletoes

The two varieties of leafy mistletoe that occur on cypresses are quite limited in extent but the incidence is heavy within infected stands. The parasite rarely kills trees but commonly causes the dying back of branches to the site of infection. Often the parasite takes over the function of the former foliage of the affected branch in keeping the latter alive.

Causal organism and type of damage	Hosts, and from where reported:
Phoradendron bolleanum (Seem.) Eichler	
var. *densum* Fosb.	*C. arizonica* U.S.A.
var. *pauciflorum* Fosb.	*C. goveniana* U.S.A.

FOLIAGE DISEASES

Causal organism and type of damage	Hosts, and from where reported:
Alternaria tenuis Nees. Blight	*C. duclouxiana* Argentina *Cupressus* sp. Tripoli
Cercospora thujina Plakidas Foliage blight	*C. arizonica* U.S.A. *C. sempervirens* U.S.A.

Causing a very prevalent foliage disease in Christmas tree plantations in the Gulf and southeastern United States of America, killing some trees and rendering others unsalable where the disease is not controlled. Dieback begins at the tips of branches and progresses toward the bole. Primarily the disease appears where Arizona cypress is grown in a climate much more humid than that of its native habitat.

Causal organism and type of damage	Hosts, and from where reported:
Coryneum asperulum Lombard & Davidson Cypress blight	*C. sempervirens* U.S.A.
Macrophoma cupressi (Cke. & Hark.) Berl. & Vog. Blight	*C. arizonica* U.S.A. *C. macrocarpa* U.S.A. *C. sempervirens* U.S.A.
Stigmatea sequoiae (Cke. & Hark.) Sacc.	*C. macrocarpa* U.S.A.

DISEASES OF LARIX[1]

by

Charles D. Leaphart[2]

Larix is the only genus of the family Pinaceae in which the leaves are deciduous and are borne on dwarf as well as on long shoots. Its near relative *Pseudolarix*, a monotype, differs only in the cones. The cone scales of *Pseudolarix* drop at maturity, but they persist in *Larix*.

The native habitat of *Larix* is limited to the northern hemisphere. In the southern part of its range, larch grows in mountainous regions, but in lowlands of the northern part, as in the U.S.S.R., it forms extensive forests. The genus includes about 10 species, some divided into varieties; reports disagree about the number of valid species found in China and the U.S.S.R. Diseases that are significant in the cultivation of larches throughout the world are reported on six of the commercially more valuable species, which are listed below with their natural ranges:

(1) *Larix decidua* Mill.
Alps; Carpathian, Sudetic, and Yugoslavian Mtns.; and the south-central hills of Poland.

(2) *Larix gmelinii* (Rupr.) Litvin (*L. dahurica* Turcz., *L. lubarskii* Suk., *L. maritima* Suk., *L. komarovii*, *L. ochotensis*, *L. middendorphii*)
Northeastern China, Korea, eastern U.S.S.R., and Kuril and south Sakhalin Islands (includes *L. gmelinii* var. *olgensis* (Henry) Ostenf. & Larsen, (*L. olgensis* Henry), and *L. gmelinii* var. *japonica* (Reg.) Pilger (*L. kurilensis* Mayr.))

(3) *Larix laricina* (Du Roi) K. Koch
Northeastern and north-central United States and eastern Canada, extending northwest into Alaska.

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(4) Larix leptolepis (Sieb. & Zucc.) Gord.
(L. kaempferi Sarg.)
Japan.

(5) Larix occidentalis Nutt.
Northern Rocky Mountains and eastern slopes of the Cascade Mountains from southern Idaho and northern Oregon in the United States into southern British Columbia in Canada.

(6) Larix sibirica Ledeb. (Includes L. sukaczewii Dyl.)
Northwestern China (L. sibirica only), and central through north European U.S.S.R.

Importance of the Group

The larches, as a group among the commercial tree species of the world, rank high in economic worth to forestry. The genus achieves its highest value as a forest resource in the U.S.S.R., where larches grow on 40.5 percent of the forested area and make up about 38 percent of the total wood reserve. *L. decidua*, *L. gmelinii*, and *L. sibirica* contribute to this reserve. The last two species are widespread, but only *L. sibirica* is cut extensively for forest products. Within their natural ranges, *L. decidua*, *L. leptolepis*, and *L. occidentalis* are often preferred in management of forest land for commercial timber production. Only *L. laricina* of the species listed has low commercial value as a timber-producing tree within its native habitat.

The wood of larch is flexible, hard, heavy, and strong, and is durable in contact with the ground or when used for underwater structures. Therefore, larch is most commonly utilized for construction lumber, poles, posts, railroad ties, and shipbuilding materials. It is used occasionally for interior finishing, plywood, and veneer stock; it can be pulped but is not a preferred species for pulping. Galactin, resin, and wood flour are products of the wood; tanning materials and textile dyes are obtained from bark, and valuable volatile oils from needles.

L. occidentalis attains the greatest size of all larches; but, like *L. gmelinii* and *L. laricina*, it has not been extensively planted as an exotic. However, *L. decidua* and *L. leptolepis* have been widely planted in the British Isles, northern Europe, and the Scandinavian countries, where they have become important components of forest stands. Larch has also been planted in the southern hemisphere; several species appear to be successful introductions, such as *L. decidua* and *L. leptolepis* in New Zealand.

Species of Larix crossbreed readily as evidenced by numerous hybrids where the natural ranges join or overlap, e.g., L. gmelinii X sibirica. Other natural hybrids, L. decidua X leptolepis, L. leptolepis X sibirica, and L. decidua X laricina, have resulted where plantations of the parent species adjoined one another, L. decidua X leptolepis is especially noteworthy because it apparently has adequate resistance to the European larch canker fungus, Dasyscyphus willkommii (Hart.) Rehm; it demonstrates one effective way of providing control of diseases--through genetic resistance.

Larches attain commercial size in natural stands commonly in mixture with other conifers; but Siberian larches, especially L. gmelinii, over large areas of northern U.S.S.R. and L. decidua at the higher altitudes of the Alps grow to commercial size in pure stands. With few exceptions, larch must initially attain and maintain a dominant position under all stand conditions to reach merchantable size because it is intolerant to shade. Thus, from the silvical aspect alone, all species are suited to management in pure, even-aged stands. Because Larix is susceptible to attack by many diseases and insects, an even-aged stand of a mixture of species appears to be a more practicable form of management for larch. This type of management is suggested particularly where exotic species of larch are cultivated.

Present and Potential Disease Impact

Examination of the lists in the disease categories that follow will reveal at least two pertinent facts. First, very few introduced diseases other than the European larch canker have so far been proved to be serious on larches. However, several pathogens could be damaging if introduced into other countries; e.g., Guignardia laricina (Saw.) Yamamoto & Ito, until now reported only in Japan. Second, and probably more important, little has been reported about the diseases in China and the U.S.S.R., the countries where larch is most abundant.

Many of the diseases in the following lists are undoubtedly more widespread than has been reported, and perhaps many may be no more damaging to other larches than they are to the hosts reported here. Nevertheless, a record of all diseases on larch and of variations in susceptibility of principal species to these diseases is needed. The profession of forestry presently has too few economical methods of supplying the world's increasing demand for wood. Being forearmed with knowledge about diseases that damage tree species preferred in management gives the forester an additional tool to use in accomplishing this objective.

The list of diseases published here admittedly is not complete. Accordingly, the author uses this opportunity to solicit advice on needed additions to and deletions from this list from more knowledgeable persons who read this report. Thus, subsequent reports may be more

nearly complete and useful in countries where larch can be cultivated. Only diseases reported on living trees are listed here. For several fungi in the listings that follow, either the most commonly used synonym or the imperfect stage is given in parentheses after the name of the fungus; otherwise only the preferred name (so far as the author can determine) is listed. Some fungi, such as *Dasyscyphus* spp., parasitize tissues having low vigor and are reported primarily because they have not been reported elsewhere; thus, their potential to cause damage to new hosts in other countries is quite unknown. Hosts are designated by the numbers enclossd in parentheses given in the list of larch species at the beginning of this report. Names of countries in which the causal organisms have been reported on larch follow the number of the host.

DISEASES OF SEEDLINGS

Many larch stands managed for timber in North America, the U.S.S.R., and some sections of Europe are reproduced by natural regeneration. Under thess conditions, diseases of seedlings have been inadequately studied. Larch is also grown in nurseries--extensively, as in Japan and Europe, or to a limited extent as in New Zealand and North America. Most knowledge about diseases of larch seedlings is founded on studies of fungi that cause damage in nurseries, and the following list is comprised of these fungi. Many of them may be distributed more widely than indicated here because all are known to infect other hosts.

Diseases caused by some fungi, such as species of *Botryotinia*, (*Botrytis*), *Cylindrocladium*, *Fusarium*, *Phytophthora*, *Pythium*, *Rhizoctonia*, and *Thelephora*, have been reported in many countries. Of these fungi, *Phytophthora cinnamomi* Rands is most notable, for it can also be a serious pathogen of older trees; it has been reported from plantations of *L. decidua* and *L. leptolepis* in New Zealand. However, these fungi are excluded from the list here because they are known to parasitize many hosts (including *Larix*) and because their international significance is already understood better than that of other pathogens of seedlings.

Some fungi, like *Guignardia laricina*, *Helicobasidium mompa* Tan., *Meria laricis* Vuill., and *Mycosphaerella larici-leptolepis* K. Ito & K. Sato, can be seriously damaging to larch seedlings. Because these fungi are generally prevalent and often damaging on older trees, they are listed in that disease category where they cause greatest damage.

Standard disease control practices and seed treatments, coupled with good nursery practices, should keep losses to a minimum in the nurseries and should reduce the risk of introducing seedling diseases to local plantation areas. Nursery stock should not be imported into new regions. Since none of the fungi in this group are known to be seed-

transmissible and since seed can be disinfected, seed should be the means of introducing species of larch into a new region, country, or continent.

Causal organism and type of damage	Hosts and where reported
Ascochyta piniperda Lindau Damping-off and needle spot	(1) Czechoslovakia
Dermatea livida (B. & Br.) Phill. (Myxosporium abietinum Rostr.) Root crown canker	(Larix sp.) Denmark
Helicobasidium purpureum (Tul.) Pat. Root rot	(Larix sp.) Netherlands; (1) Germany
Memnoniella echinata (Riv.) L.D. Gall. Damping-off	(4) Gt. Brit.
Pellicularia filamentosa (Pat.) Rogers (Rhizoctonia solani Kuehn) Root rot and web blight of stems	(4) Belgium, Japan
Rhizina inflata (Schaeff.) Karst. (R. undulata Fr.) Root rot in nurseries but also associated with group dying of conifers in plantations	(1) Germany, Gt. Brit.; (4) Gt. Brit., Netherlands; (5) U.S.A.; (6) Sweden
Sclerotinia kitzjimana Ito & Hosaka Seedling blight, often associated with Botrytis cinerea Pers. ex Fr.	(4) Japan
Sclerotium bataticola Taub. (Macrophomina phaseoli (Maubl.) Ashby) Damping-off and root rot	(3) U.S.A. (by inoculations); (4) Japan

ROOT DISEASES

Root diseases are a special problem in management of plantations and other forest stands. Many of their causal organisms can persist as saprophytes, yet may be very pathogenic on numerous host species under a variety of circumstances.

Of the fungi listed below, only Helicobasidium mompa and Sparassis radicata Weir are confined strictly to the roots of trees. All others cause butt rot as well as root rot but their induced rot

columns rarely extend more than a few feet up the trunk. H. mompa and Poria weirii Murr. are so far reported to have restricted distribution, but all fungi considered in this disease group are pathogenic on other conifers.

Three of the most serious root disease fungi of larches are excluded from the list that follows. Armillaria mellea (Fr.) Quel. and Fomes annosus (Fr.) Cke. are reported on the six larch species listed at the beginning of this report. Another cosmopolitan fungus, Polyporua schweinitzii Fr., is reported on all of these larches except L. sibirica, which is undoubtedly susceptible though not yet a recorded host. These three fungi are also important root and butt decay organisms in larch.

In established infection centers, eradication of root diseases is impractical under current forestry practices, but losses can be reduced in succeeding rotations by planting more resistant species. Prevention of infection by F. annosus has recently been accomplished by treating stumps with recommended chemicals.

Causal organism and type of damage	Hosts and where reported
Clitocybe tabescens Bres. Root rot like A. mellea; Clitocybe sp. has been reported on L. decidua in Gt. Brit.	(4) Japan
Coniophora puteana (Schum. ex. Fr.) Karst. Brown cubical root and butt rot	(1, 4) Gt. Brit.; (5) Canada
Corticium galactinum (Fr.) Burt White stringy root and butt rot	(3, 5) Canada
Helicobasidium mompa Tanaka Violet root rot, one of most important soil-borne diseases in Japan on seedlings and older trees. Also known in Formosa and Korea and especially notable as a potentially serious pathogen if introduced to other continents	(1, 4) Japan
Odontia bicolor (Alb. & Schw. ex Fr.) Quél. Root parasite and white root and butt rot	(2, 3) Canada
Polyporus berkeleyi Fr. White stringy root and butt rot; wound parasite	(5) U.S.A.

Polyporus tomentosus Fr. (including P. circinatus Fr.) White root and butt rot	(3) Canada; (4) Japan (5) U.S.A.
Poria subacida (Pk.) Sacc. White stringy root and butt rot	(4) Japan (5) U.S.A.
Poria weirii Murr. White root and butt rot but also a destructive root parasite, so far known only in Japan and northwestern North America	(4) Japan (5) Canada, U.S.A.
Sparassis crispa (Wulf.) Fr. Brown root and butt rot	(4) Japan
Sparassis radicata Weir Root parasite and brown root rot	(5) U.S.A.

STEM DISEASES

Cankers and Diebacks

The potential threat to larch hosts of most of the canker diseases is unknown. Several of the causal organisms, such as Dasyscyphus willkommii and Phacidiella coniferarum Hahn, have a great variety of larch hosts. The former is extremely pathogenic on some larches introduced into Europe, e.g., L. occidentalis. Many of the canker fungi listed here have been reported on other conifers; notable exceptions are Crumenula laricina, D. willkommii, Guignardia laricina, and Tympanis laricina, which are known only on species of Larix. G. laricina is an extremely destructive pathogen and is known only in Japan. This fungus merits special attention for purposes of quarantine in other countries because such species as L. decidua and L. occidentalis, introduced to Japan, have proved to be much more susceptible than the native L. leptolepis.

Adequate quarantine should be imposed against all of these fungi because the potential of many of them to cause damage to different hosts in their natural habitat is unknown. Where the more damaging fungi have become well established, no practical control methods have been developed; but proper selection of species and sites for planting and keeping growth at its maximum rate for these sites will most likely reduce damage.

Causal organism and type of damage	Hosts and where reported
Aleurodiscus amorphus ((Pers.) Fr.)) Rag. Branch canker; weakly parasitic	(3, 5) U.S.A.

Coniothyrium fuckelii Sacc.
Branch and stem canker; weakly parasitic

(1) Gt. Brit.

Crumenula laricina Ettl.
Twig dieback and needle case

(*Larix* sp.) Switzerland;
(1) Germany

Cytospora sp.
Stem canker

(3,4) Canada

Cytospora curreyi Sacc.
Branch and stem canker

(*Larix* sp.) Switzerland;
(1) Gt. Brit.;
(3, 5) Canada

Dasyscphus (*Lachnellula*, *Trichoscyphella*) spp.

Of the species listed, *D. aridus*, *D. calyciformis*, *D. ellisianus*, and *D. oblongosporus* are reported only on dead branches. Because of wide distribution of some species in North America and reported parasitism of larches by others, all are listed in this group of diseases:

D. aridus (Phill.) Sacc.

(5) U.S.A.

D. calyciformis (Wild.) Rehm

(1) Switzerland
(5) U.S.A.

D. hahnianus Seaver (*D. calycinus* (Schum.) Fckl.)
Generally saprophytic, but may be weakly parasitic according to some inoculations

(1) Gt. Brit. (by inoculations, Norway;
(1,3,4) U.S.A. (by inoculations);
(5) Canada

D. ellisianus (Rehm) Sacc.

(1, 4) U.S.A.

D. oblongosporus Hahn & Ayers

(1, 3, 4) U.S.A.;
(3) Canada

D. occidentalis Hahn & Ayers
Twig canker

(1,3, 4) U.S.A.;
(5) Canada and U.S.A.

D. resinarius (Cke. & Phill.) Rehm
Branch and stem canker

(1, 6) Gt. Brit.

D. willkommii (Hart.) Rehm
Branch and stem canker. Of all diseases of larches, this disease has received most publicity for causing high economic losses.

(1) British Isles; Baltic, European, Scandinavian countries; Japan; U.S.S.R.;
(2) Japan, Scandinavia, U.S.S.R.;

No larch species is completely immune, and present experience suggests that the disease is most damaging to larches planted "off-site" or outside their natural ranges. Since it has not yet become permanently established in the natural habitat of some species, special measures should be imposed to prevent its import into these areas.	(3) British Isles, Europe, Norway; (4) European and Scandinavian countries, Japan; (5) British Isles, Denmark, Europe, Japan; (6) Gt. Brit., European and Scandinavian countries.
Diaporthe conorum (Desm.) Niessl. (*Phomopsis occulta* Trav.) Branch and stem canker; Weakly parasitic	(1) Japan (4) Denmark, Japan
Dothichiza pithyophila (Cda.) Petr. (*Sclerophoma pithyophila* (Cda.) Hoehn.) Branch and stem canker	(1) Germany
Guignardia cryptomeriae Saw. (*Macrophoma sugi* Hara) Twig dieback	(1, 4) Japan
Guignardia laricina (Saw.) Yamamoto & Ito (*Physalospora laricina* Saw.) Twig dieback; most serious disease of larches in Japan and, potentially, the most serious disease threat to larches elsewhere	(1,2,4,5) Japan
Hysterographium fraxini (Fr.) de N. Branch and stem canker; weakly parasitic	(1) Switzerland
Nectria cucurbitula Fr. Dieback of twigs; weakly parasitic; *Nectria* sp. reported on *L. leptolepis* in Gt. Brit.	(1) Germany
Phacidiella coniferarum Hahn (*Phomopsis pseudotsugae* M. Wils.) One of the serious canker diseases of larches	(1,4,6) Czechoslovakia, Germany, Gt. Brit., Netherlands, Norway; (1,4,5) U.S.A.; (4) Sweden

Tympanis laricina (Fckl.) Sacc. Branch and stem canker; weakly parasitic	(Larix sp.) Austria; (1,3, 5) Canada
Valsa abietis Fr. Twig canker; weakly parasitic	(1) Gt. Brit.; (3) Canada
Valsa kunzei Fr. Twig canker; weakly parasitic	(3) U.S.A.

Decays and Stains

Considerable of the volume in mature larch stands of Europe, North America, and the U.S.S.R. is defective because of decay. The causal organisms of decay in both immature and mature larch stands have received little attention compared to those in fir, pine, or spruce stands; and the decay fungi reported on larches are known best for their associations with other conifers. Of the decay fungi, Fomes pini (Thore ex Fr.) Karst. is widespread, is found on the six species of larch, and, therefore, is not included in the list that follows. However, it is probably the most damaging stem decay fungus in management of plantations or natural second-growth stands. Intensive management, including pruning and prevention of wounds, and shorter rotations appear to be the most practicable means of keeping decay losses at a minimum.

Causal organism and type of damage	Hosts and where reported
Ceratocystis spp. Blue stain of sapwood. Associated with bark beetles	
C. autographa Bakshi	(4) Scotland
C. galeiformis Bakshi	(4) Scotland
C. ips (Rumb.) C. Moreau	(5) U.S.A.
C. minor (Hedgc.) Hunt	(5) U.S.A.
C. piceae (Münch) Bakshi	(4) Japan, Scotland
Fomes cajanderi Karst. (F. subroseus (Weir) Overh.) Stem rot (brown)	(3) U.S.A.; (5) Canada, U.S.A.
Fomes nigrolimitatus (Rom.) Egel. Stem rot (white pocket)	(5) Canada, U.S.A.

Fomes officinalis (Vill. ex Fr.) Faull Stem rot (brown cubical). Second to F. pini in amount of decay damage in larches	(1) Austria, France, Italy, Switzerland, U.S.S.R.; (2) Japan, Sakhalin Is., U.S.S.R.; (3) Canada, U.S.A.; (4) Japan; (5) Canada, U.S.A.; (6) U.S.S.R.
Fomes pinicola (Swartz ex Fr.) Cke. Butt and stem rot (brown crumbly)	(3, 5) Canada, U.S.A.; (4) Japan
Fomes robustus Karst. Stem rot (white)	(4) Gt. Brit.
Fomes roseus (Alb. & Schw. ex Fr.) Cke. Stem rot (brown cubical)	(5) Canada, U.S.A.
Hypholoma fasciculare (Huds.) Fr. Stem rot (brown)	(1, 4) Gt. Brit.
Merulius himantioides Fr. Stem rot (brown cubical)	(1) Gt. Brit.; (3) Canada
Polyporus sulphureus Bull. ex Fr. Stem rot (brown cubical); a damaging decay fungus in larches	(1) Germany, Gt. Brit., Switzerland, U.S.S.R.; (2) U.S.S.R.; (5) Canada, U.S.A.
Stereum chailletii (Pers. ex Fr.) Fr. Stem rot (white)	(5) Canada
Stereum sanguinolentum (Alb. & Schw. ex Fr.) Fr. Butt, stem, and occasionally root rot (brown); a damaging decay fungus in larches	(1) Gt. Brit., Norway, U.S.A.; (3) Canada; (5) U.S.A.

Mistletoes

Only the larch dwarfmistletoe, Arceuthobium campylopodum f. laricis, causes serious damage to larch. A. pusillum, a damaging pathogen on Picea mariana (Mill.) B.S.P. in North America, rarely infects larch under natural conditions. The larch dwarfmistletoe is found throughout the natural range of its primary host, but occasionally damages other conifers growing in infested larch stands. The parasite can be controlled through recommended silvicultural procedures.

Causal organism and type of damage	Hosts and where reported
Arceuthobium campylopodum Engelm. f. *campylopodum* (Engelm.) Gill Inoculations only	(1, 5) U.S.A.
Arceuthobium campylopodum Engelm. f. *laricis* (Piper) Gill Inoculations only on (1) and (4)	(1, 4, 5) U.S.A.; (5) Canada
Arceuthobium pusillum Peck	(3) Canada, U.S.A.
Viscum album L. Inoculations only	(4) Germany

FOLIAGE DISEASES

Most foliage diseases on larches cause relatively small economic losses, although several of the causal fungi, such as *Hypodermella laricis* and *Meria laricis*, are widespread and periodically become epiphytotic, causing severe damage locally. *M. laricis* sometimes is a serious disease in European nurseries, and controls have been recommended. In addition to these two fungi, three of the fungi listed, i.e., *Lophodermium laricinum*, *Mycosphaerella larici-leptolepis*, and *M. laricina*, are restricted in hosts to species of *Larix*. *M. larici-leptolepis*, reported only from Japan, causes a serious foliage disease of several larch species. It appears to be the only one of this disease group that might cause severe losses if introduced into other larch-producing countries and, thus, might receive special quarantine measures. The needle rusts are relatively unimportant on *Larix*, but we need to know more about the potential dangers from some of them. No controls for foliage diseases in natural larch stands and plantations have been recommended as practicable measures in present-day forestry.

Causal organism and type of damage	Hosts and where reported
Cercospora exosporioides Bub. Needle spot	(1) Czechoslovakia; (4) Japan
Cladosporium epiphyllum (Pers.) Martius Black mold	(1,4) Gt. Brit.
Cladosporium laricis Sacc. Needle spot and mold	(1) Italy, ? U.S.A.
Hypodermella laricis Tub. Needle blight; occasionally kills spur shoots	(1) Austria, Germany, Switzerland; (2) U.S.S.R.; (3) Canada, U.S.A.; (5) Canada, U.S.A.

Lophodermium laricinum Duby Needle cast	*Larix* sp., Japan; (1) Austria, Germany, Italy, Switzerland; (3, 5) Canada; (6) U.S.A.
Lophodermium pinastri (Schrad. ex Fr.) Chev. (*L. laricis* Dearn.) Needle cast	(5) Canada, U.S.A.

Melampsora spp.
Needle rust. Several species that are common and widespread on their telial hosts (*Salix* and *Populus*) occasionally infect larch needles. All six major species of *Larix* are attacked, but no significant damage is recorded.

Melampsoridium spp.
Needle rust. Three species are common and widespread on their telial hosts (*Alnus* and *Betula*). These fungi seldom infect larches and no damage has been reported.

Meria laricis Vuill. Needle cast	(1) Austria, British Isles, Czechoslovakia, Denmark, France, Germany, Italy, Netherlands, New Zealand, Norway, Sweden; (2) Gt. Brit.; (4) Gt. Brit., New Zealand, Norway; (5) Canada, Gt. Brit., U.S.A.; (6) Norway, U.S.S.R.
Mycosphaerella larici-leptolepis K. Ito & K. Sato Needle cast	All six species, Japan
Mycosphaerella laricina (Hart.) Neg. Needle cast	(1) Germany, Sweden; (4) Germany

DISEASES OF PICEA (OTHER THAN P. ABIES)[1]

by

Roger S. Peterson[2]

Four species of spruce form a broad belt of forests around the northern hemisphere: *Picea glauca* (Moench) Voss and *P. mariana* (Mill.) B.S.P. in North America and *P. abies*(L.) Karst. and *P. obovata* Ledeb. in Eurasia. Three additional species complete this belt near the Pacific: *P. jezoensis* Carr. and *P. koyamai* Shiras. in Asia and *P. sitchensis* (Bong.) Carr. in North America. Others are in the mountains southward from this boreal zone. Notable montane species are *P. engelmannii* Parry ex Engelm. and *P. pungens* Engelm. in western North America; *P. rubens* Sarg. in eastern North America; *P. orientalis* Lk. in the Caucasus and Turkey; *P. schrenkiana* Fisch. & Mey. in Turkestan; *P. asperata* Mast. and *P. likiangensis* Pritz in China, *P. glehnii* Mast. in Japan, and *P. smithiana* Boiss. in the Himalayas. Another 12 to 26 species (the number varies with the viewpoint of the taxomist) bring the total in the genus to 28 or 42. Most of the less widespread species are in China and Japan.

Botanists usually distinguish two groups within *Picea*: section *Picea*, characterized by quadrangular needles with stomata on all sides; and section *Omorika*, having flatter needles with stomata on only one surface. Biochemical differences between these sections are reported, but recent analysis of many morphological characters and of crossbreeding patterns suggests that this sectional division is not valid. Susceptibility of species to diseases tends to confirm the idea that *Picea* is a remarkably homogeneous group: few instances are known of proven resistance of a spruce species to a pathogen that infects any member of the genus.

Picea abies, of Europe, is discussed in a separate review in this series. The present paper treats diseases of all other spruce species.

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2 Intermountain Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Ogden, Utah.

Importance of the Group

Spruces are generally tall trees of little taper. They produce moderately long-fibered wood that is well suited for pulping, its major use. Spruce lumber is straight grained and strong for its weight, but inferior in nail-holding capacity to lumber from Douglas-fir and many pines.

Within much of the subarctic zone, spruces are the most abundant timber species. Judged by volume of growing stock, *Picea* is by far the leading genus in Canada and Alaska and is third (after *Larix* and *Pinus*) in the U.S.S.R. Spruce is abundant also in northwestern Europe, Japan, China, and the Himalayas. It is relatively less common in central Europe and in the contiguous United States, and unimportant further south. Southern limits of natural distribution are at about latitude 25°N. in Mexico.

Commercial use is not proportional to volume figures for spruce. Because of inaccessibility of both northern taiga and the high-elevation spruce further south, other forest types are often used in preference. The *P. glauca* forests of interior Alaska are an example of under-utilization caused by lack of close markets. Slow growth in many regions and frequent failures in natural regeneration of many species also discourage dependence on spruce as a source of timber.

Of species discussed here (see also *P. abies*), *P. sitchensis* is the spruce most used for planting as an exotic. Its relatively fast growth in cool sites and its tolerance to very acid soils suit it to reforestation and afforestation projects in parts of northern Europe and Iceland, for instance in *Calluna* heath. It has also been used on sites that do not meet its exacting moisture requirements; many such plantations have failed.

Picea glauca, *P. engelmannii*, and *P. koyamai* have also been used in large forest plantings, but in general the notable successes have been within their natural ranges. Experience suggests that outside their ranges (in New Zealand for instance), spruces generally have advantages over other conifers only on certain carefully selected sites. Suitability of sites may be hard to predict. An example is the superior growth of *P. omorika* Purk. (native to the Drina basin in Yugoslavia) on dry, calcareous slopes in Germany--not the usual "spruce site." It seems probable that more areas in which spruce excels will be found if forestation efforts increase in cold environments, as in the Andes.

Present and Potential Disease Impact

No catastrophic disease problems are peculiar to spruces, but the group has its share of parasites and decay organisms that kill, reduce growth rates, and lessen the value of trees. Among the most important organisms are those causing root disease and decay, including the widely distributed species *Armillaria mellea* (Fr.) Quél., *Fomes annosus* (Fr.) Cke., and *Polyporus tomentosus* Fr. Among fungi commonly causing trunk decay in living spruce are *Fomes pini* (Fr.) Karst., *Polyporus sulphureus* Fr., and *Stereum sanguinolentum* (Fr.) Fr. Control of damage by these fungi is among the prime requirements in management of spruce in both Eurasia and North America. In plantations, emphasis must be placed on control of the fungi that cause root disease. European plantations of *Picea sitchensis*, for example, have proved especially vulnerable to *Rhizina undulata* Fr. -- probably because sites on which this spruce is planted are especially favorable to this fungus.

In contrast to these widespread decay fungi, several stem parasites of spruce are thought to be limited in distribution, and therefore are more relevant to discussion of the spread of internationally dangerous forest pests. Some cause severe damage in their present ranges, for instance the incitants of bud blight in northern Europe and dwarfmistletoe and broom rust in North America. Others have little importance now but might become damaging in other environments. In the latter group are such fungi as *Atropellis treleasei* (Sacc.) Zell. & Good. and *Dasyscyphus abieticolus* Henn. & Shir., which are regarded as weak (often secondary) parasites. New combinations of climate and spruce host might tip the balance in their favor and give rise to serious losses.

Lists of some of the parasites of spruce follow. Brief mention is made of the more important species that are known from major spruce regions throughout Europe, Asia, and North America; species having only limited distribution are listed separately.

SEEDLING DISEASES

Diseases of spruce seedlings are generally caused by the same fungi that infect many other conifers. Important fungus genera associated with damping-off, root diseases, and stem blights of *Picea* seedlings are *Botrytis* (perfect stage: *Botryotinia*, *Sclerotinia*), *Cylindrocladium*, *Diplodia*, *Diplodina*, *Dothichiza*, *Fusarium*, *Fusoma*, *Memnoniella*, *Pestalotia*, *Phoma*, *Phomopsis*, *Rhizoctonia* (perfect stage: *Ceratobasidium*, *Corticium*, *Helicobasidium*, *Pellicularia*), *Rosellinia*, *Phytophthora*, and, perhaps most damaging of all, *Pythium*. Snow blights and smothering diseases are caused by

Herpotrichia, Neopeckia, Lophophacidium ("Phacidium"), Sarcotrichila, Thelephora, and others. Even with broadly conceived taxa it appears no fewer than 35 fungus species have caused losses in spruce (other than Picea abies) in nurseries. Most of these are widespread, but several have not been studies enough to determine their distributions. Examples of the latter group follow.

Causal organism and type of damage	Hosts, distribution
Ascochyta piniperda Lind. (Septoria parasitica Hart.) Twig blight and (reportedly) damping-off	Picea sitchensis, P. spp.; western Europe; on other hosts widespread in Europe, local in eastern U.S.A. (where it may be native)
Cucurbitaria piceae Borth. Bud blight	(See below under "Stem Diseases")
Hyalostachybotrys sp. Root disease	Picea glauca; Canada; also in other conifers
Phytophthora cinnamomi Rands Damping-off	Picea pungens; southeastern U.S.A. On other hosts the fungus is on all continents except Antarctica; largely tropical but may be spreading to the temperate zones.
Racodium therryanum Thuem. Snow blight	Picea jezoensis; Japan; on other conifers in Japan and Europe
Rhizina undulata Fr. Root disease	(See below under "Root Diseases")
Rhizoctonia dichotoma Saks. & Vaar. Damping-off; an example of Rhizoctonia spp. of limited distribution; others (as R. solani Kuehn) are widespread	Picea glauca; Canada
Sclerotinia kitajimana Ito & Hos. Snow mold	Picea jezoensis; Japan; also on many other plants

Nematodes, as well as fungi, cause disease in seedlings. Little is known about their effects on Picea. Species of Criconemoides, Xiphinema, and others have been thought to cause disease in spruce seedlings or to make possible the entrance of fungi that cause

disease. The dangers of international transport of nematodes cannot properly be assessed until more is known about species distribution and pathogenicity.

ROOT DISEASES

Fungi that cause death of roots are of great and growing importance where spruce is managed intensively. One group of root parasites also causes heart rot; these are mainly Basidiomycetes and a few Ascomycetes. Other pathogens are ordinarily limited to rootlets and the outer tissues of larger roots; these are mainly Phycomycetes, Fungi Imperfecti, and Thelephoraceae. There are few known examples of the latter group affecting spruce except in seedlings; scattered reports of "*Pythium* sp." and a few others in older trees do not give any basis for discussion of international problems from rootlet pathogens.

Widespread species of the heart rot group that cause root disease of spruce are *Armillaria mellea* (Fr.) Quél., *Fomes annosus* (Fr.) Cke., *Polyporus schweinitzii* Fr., *P. tomentosus* Fr., and *Rosellinia aquila* (Fr.) de N. Many other widely distributed fungi that cause butt rot may also be somewhat parasitic in roots; these are listed (as butt rots) under "Trunk Rots." A few fungi of the root rot group are limited in distribution, including the following:

Causal organism and type of damage	Hosts, distribution
Poria weirii Murr. Root rot	Several *Picea* spp.; northwestern North America, Japan; mainly on other conifers
Rhizina undulata Fr. Root rot	*Picea sitchensis*; western Europe. Widespread in Europe and North America on many conifer hosts
Sparassis crispa Fr. Root rot	*Picea glehnii*, *P. jezoensis*, *P. sitchensis*; Germany, Japan; widespread in Europe and Asia on other hosts
Sparassis radicata Weir Root rot	*Picea engelmannii*; U.S.A.

STEM DISEASES

Stem parasites of spruce are in two distinct groups in respect to parasitism. The rust fungi and mistletoes that cause malformations

and loss of increment are obligate parasites; they tend to attack the more vigorous trees. Ascomycetes, Fungi Imperfecti, and Thelephoraceae associated with bark necrosis are generally weak parasites; they are most common where site or stand conditions are not entirely suited to growth of spruce. It does not follow that the latter group of pathogens is unimportant: it might be possible for trees to recover completely from a period of adverse weather, for instance, were it not for invasion by weakly parasitic organisms.

Many of the weak parasites are known throughout the natural range of spruce; examples are Cucurbitaria pithyophila (Fr.) de N., Dasyscyphus calyciformis (Willd.) Rehm, Diaporthe eres Nits. (Phomopsis spp.), Diplodia pinea (Desm.) Kickx (Sphaeropsis ellisii Sacc.), and Valsa kunzei (Fr.) Fr. (Leucostoma; Cytospora). Most of the obligate parasites, on the other hand, have limited distributions. "Less widespread" organisms in both categories are included in the following list, but some of these are undoubtedly more widely distributed than this compilation shows.

Causal organism and type of damage	Hosts, distribution
Aleurodiscus amorphus (Fr.) Rab. Stem canker (?); at most, weakly parasitic on spruce	Several spruce species; Canada, U.S.A.
Arceuthobium campylopodum f. microcarpum (Engelm.) Gill Dwarfmistletoe; growth loss and brooming	Picea engelmannii, P. pungens; southwestern U.S.A.
Arceuthobium pusillum Pk. Dwarfmistletoe; growth loss and brooming	Picea glauca, P. mariana, P. rubra; eastern Canada, eastern U.S.A.
Arceuthobium spp. Dwarfmistletoes normally found on other conifers occasionally infect spruce	Picea spp.; western North America
Ascochyta piniperda Lind. Twig blight and dieback	(See "Seedling Diseases," above)
Atropellis treleasei (Sacc.) Zell. & Good. /_ Godronia treleasei (Sacc.) Seav._/ Possibly causes cankers	Picea sitchensis; Alaska

Cenangium ferruginosum Fr. Possibly causes branch dieback	*Picea engelmannii*, *P. glauca*; western U.S.A., western Canada. Widespread in Europe and North America on other hosts
Chrysomyxa arctostaphyli Diet. Brooming and growth loss. The alternate hosts (*Arctostaphylos* spp.) are commonly associated with *Picea* in Eurasia. This is perhaps the most dangerous spruce parasite of presently limited distribution	*Picea* spp.; U. S. A., Canada
Chrysomyxa deformans (Diet.)Jacz. Deforms current-year shoots. Autoecious	*Picea jezoensis*, *P. schrenkiana*, *P. smithiana*; Himalayas, Kazakhstan, Japan
Chrysomyxa woronini Trans. Stunts current-year shoots. If telial stage is truly limited to *Ledum palustre* L., this rust may already have reached its distribution limits	*Picea glauca*, *P. mariana*, *P. obovata*; northern taigas of Eurasia and North America; possibly southward in China on *P. likiangensis*
Cucurbitaria piceae Borth. Deforms and kills buds and shoots. Locally damaging now; potentially very serious	*Picea glauca*, *P. pungens*, *P. sitchensis*; Britain, Denmark Germany, Switzerland
Dasyscyphus (*Lachnellula*, *Trichoscyphella*) spp. About eight species on *Picea*, of doubtful pathogenicity. Some may cause cankers or twig death	Examples of species of limited distribution: *D. abieticolus* Hen. & Shir. on *Picea jezoensis* in Japan; *D. oblongospora* Hahn & Ay. on *P. pungens* in eastern U.S.A.
Dothichiza pithyophila (Cda.) Petr. Associated with top and branch dieback	*Picea engelmannii*; western Canada. On other conifers widespread in Europe and North America
Leptographium (*Ceratocystis*) spp. Some of these sapwood-staining organisms may impair conduction or cause bark necrosis. Associated with bark beetles	*Picea* spp.; throughout Eurasia and America. Some of the fungus species are limited in distribution, as *L. engelmannii* Dav. on *P. engelmannii* in western U.S.A.

Nectria cucurbitula Fr. (_Scolonectria_; _Cylindrocarpon_) Associated with stem cankers and basal stem fluting; weakly parasitic	_Picea sitchensis_ and other species; U.S.A., Britain, Scandinavia, central Europe
Pezicula livida (Berk. & Br.) Rehm (_Dermatea_; _Myxosporium_) Associated with diseased bark but may be saprophytic	_Picea sitchensis_; Britain. Widespread on other conifers in Europe and North America
Pezicula rohdeana Kirsch. Associated with stem cankers	_Picea sitchensis_; Germany
Phacidiella coniferarum Hahn (_Phacidiopycnis_, _Phomopsis_) Associated with dead bark	Inoculations on _Picea_ spp. On other conifers in western Europe, eastern U.S.A., and New Zealand
Pullularia pullulans (de B.) Berkh. (_Aureobasidium_) Possibly causes bud necrosis	_Picea glauca_; western Canada. Widespread on other conifers in North America and Europe
Retinocyclus abietis (Cr.) Groves & Wells Associated with cankers (but sporulating on resin); pathogenicity uncertain	_Picea engelmannii_, _P. glauca_; western Canada. On other conifers widespread in Europe and North America
Therrya (_Coccophacidium_) sp. Associated with dieback. Known _Therrya_ spp. are normally on _Pinus_	_Picea glauca_; western Canada
Tryblidiopsis pinastri (Pers.) Karst. Associated with cankers and dieback	_Picea mariana_, _P. sitchensis_; Canada, northern U.S.A. On other conifers widespread in America and Europe
Tympanis piceae Groves May be weakly parasitic	_Picea glauca_; Canada. Also found in Sweden
Tympanis piceina Groves May be weakly parasitic	_Picea glauca_; eastern U.S.A. Also found in Sweden
Viscum album L. Causes swellings and growth loss, but does little damage to spruce	_Picea pungens_, _P. sitchensis_; widespread in Europe. Mostly on other trees

TRUNK ROTS

In the past, heart rot has been the most important pathological problem in spruce management. It may still be so today, although at least its relative importance decreases as old-growth stands are removed. Like the fungi that cause seedling diseases, the decay organisms are generally widespread and unspecialized--that is, they attack other conifers in addition to spruce. *Fomes pini* (Fr.) Karst. is the most important species in both Eurasia and North America; it is reported from 13 species of *Picea*. Differences in species susceptibility to *F. pini* have been reported, for instance Ch'en's statement that in China *P. asperata* is more resistant than *P. purpurea*, but this may be based on age or site differences of the hosts. Other circumboreal fungi that commonly cause heart rot of living spruce are:

Causing Brown Trunk Rot

Fomes cajanderi Karst. [incl. *F. subroseus* (Weir) Overh.]
F. officinalis (Fr.) Faull
F. pinicola (Fr.) Cke. (esp. on *Picea sitchensis*, *P. smithiana*)
F. roseus (Fr.) Karst.
Polyporus fibrillosus Karst. (esp. on *Picea sitchensis*)
P. sulphureus Fr.
Poria albolilacina (Karst.) Sacc. incl. *Poria monticola* Murr., *P. microspora* Overh.)

Causing White Trunk Rot

Fomes nigrolimitatus (Rom.) Engel.
F. robustus Karst.
Polyporus borealis Fr.
P. resinosus Fr.
Stereum chailletii (Fr.) Fr.
S. sanguinolentum (Fr.) Fr.

Causing Brown Butt Rot

Coniophora cerebella Pers. [Incl. *C. puteana* (Fr.) Karst.]
C. olivacea (Fr.) Karst.
Polyporus balsameus Pk.
P. schweinitzii Fr.
Poria sericeomollis (Rom.) Baxt. [Incl. *Poria asiatica* (Pilát) *Leptoporus litschaurii* Pilát]

Causing White Butt Rot

Armillaria mellea (Fr.) Quél.
Corticium galactinum (Fr.) Burt
Fomes annosus (Fr.) Cke.
Ganoderma applanatum (Gray) Pat.
Polyporus tomentosus Fr. (incl. *Polyporus circinatus* Fr.)
Stereum sulcatum Burt

Many other fungi that are ordinarily found in slash, stumps, or timber in service sometimes cause decay of heartwood in living trees. Examples of widespread fungi in this category are *Lentinus lepideus* Fr., *Paxillus panuoides* Fr., *Peniophora gigantea* (Fr.) Mass., *Polyporus immitis* Pk., *P. versicolor* Fr., *Serpula lacrimans*

var. himantoides (Fr.) W. Cke., Trametes heteromorpha (Fr.) Bres., and T. serialis Fr. Pholiota adiposa Fr. and P. squarrosa Fr. exemplify those fungi ordinarily found in hardwoods that occasionally decay spruce and other conifers.

Important spruce decay fungi that are not known to be so widespread are listed below:

Causal organism and type of damage	Hosts, distribution
Echinodontium tinctorium Ell. & Ev. White trunk rot	Picea engelmannii, P. glauca; western Canada, western U.S.A. Mostly on other conifers in North America and Japan
Flammula alnicola (Fr.) Kumm. White butt rot	Picea engelmannii, P. glauca, P. mariana; U.S.A., Canada. Common on other plants in North America and Europe
Fomes ?carneus Nees "Relatively rapid" heart rot	Picea likiagensis; China
Fomes jezoensis Aosh.; Cryptoderma yamanoi Imaz. White trunk rot. Fungi may not be distinct from Fomes pini	Picea jezoensis; Japan
Helicobasidium corticioides Band. Associated with brown butt rot	Picea engelmannii; western U.S.A.
Lentinus kauffmanii Smith ex Bier & Nobl. Brown butt or trunk rot	Picea sitchensis; western Canada, Alaska
Odontia bicolor (Fr.) Bres. White butt rot	Picea glauca, P. mariana; Canada. Widely distributed on other hosts in North America and Europe
Peniophora pseudo-pini Weres. & Gibs. Brown trunk rot	Picea glauca; Canada. Mostly on Pinus in Canada, U.S.A.
Peniophora septentrionalis Lau. White trunk rot	Many spruce species; widespread in Europe and North America

Polyporus osseus Kalch. Brown butt rot	*Picea engelmannii*, *P. sitchensis*; western U.S.A., western Canada. Widely distributed on other hosts in North America and Europe
Polyporus stipticus Fr. (incl. *P. guttulatus* Pk.) Brown butt rot; more frequent in slash	*Picea mariana* and other species; Canada, northern U.S.A. On other hosts widely distributed in Europe and North America
Poria subacida (Pk.) Sacc. (incl. *P. colorea* Overh. & Engl.) White butt rot	*Picea glehnii*, *P. jezoensis*, and North American species; Japan, U.S.A., Canada. Also in Central America on other hosts
Poria weirii Murr. White butt rot	*P. jezoensis*, *P. sitchensis*; Japan, U.S.A., Canada. Mostly on other conifers
Sparassis crispa Fr. Brown butt rot	*Picea glehnii*, *P. jezoensis*, *sitchensis*; Germany, Japan. Widespread in Eurasia on other hosts
Xeromphalina campanella (Fr.) Kühn. & Maire Brown butt rot	*Picea glauca*, *P. sitchensis*; Canada. On other hosts widespread in Europe and North America

NEEDLE DISEASES

Many Ascomycetes and Uredinales kill spruce needles. Occasionally they cause measurable growth loss, but foliage diseases are less important than any of the groups discussed thus far. One of the most widespread and damaging needle fungi is *Lophodermium piceae* (Fckl.) Hoehn., known on at least eight *Picea* species in Eurasia and America. *Chrysomyxa ledi* (Alb. & Schw.) de B. and *C. ledicola* (Pk.) Lagh., with alternate hosts in the Ericaceae, are circumboreal species reported on 11 of the northernmost spruce species. *C. empetri* (Pers.) Schroet. ex Jørs., *C. chiogenis* Diet., and *Pucciniastrum arcticum* (Lagh.) Trans. are widespread on their alternate hosts (*Empetrum*, *Chiogenis*, and *Rubus*, respectively) but probably do little or no damage to spruce. Less widely distributed species are listed below. The snow blight fungi, some of which were mentioned as seedling diseases, are not listed here even though they infect the lower parts of older trees. Nor are species of *Chrysomyxa* repeated here that were listed under "Stem Diseases,"

though they also cause premature loss of needles.

Causal organism and type of damage	Hosts, distribution
Bifusella crepidiformis Dark. Needle cast	Picea glauca, P. mariana; Canada
Ceropsora piceae (Barcl.) Bakshi & Singh Needle rust. Autoecious	Picea smithiana; Himalayas
Chrysomyxa abietis (Wallr.) Ung. Needle rust. Autoecious Locally damaging	Picea spp.; widespread from Britain to Japan
Chrysomyxa expansa Diet. Needle rust. Alternates to Rhododendron. Provides unusual example of specialization within Picea; P. glehnii is said to be immune	Picea jezoensis; Japan, China
Chrysomyxa himalensis Barcl. Needle rust. Alternates to Rhododendron	Picea smithiana; Himalayas
Chrysomyxa piperiana Sacc. & Trott. ex Cumm. Needle rust. Alternates to Rhododendron	Picea sitchensis; western U.S.A., western Canada
Chrysomyxa roanesis (Arth.) Arth. Needle rust. Alternates to Rhododendron	Picea rubens; eastern U.S.A.
Chrysomyxa succinea (Sacc.) Trans. Needle rust. Alternates to Rhododendron	Picea jezoensis; Japan, Siberia
Chrysomyxa weirii Jacks. Needle rust. Autoecious	Picea spp. in Canada, U.S.A.: P. schrenkiana in Kazakhstan
Diedickea piceae Bon. Needle cast	Picea sitchensis; California
Lophodermium crassum Dark. Needle cast	Picea breweriana Wats.; California

Lophodermium macrosporum (Hart.) Rehm (incl. *L. filiforme* Dark.) Needle cast. Locally damaging	Many spruce species; widespread in Europe and North America
Lophophacidium hyperboreum Lag. (*Phacidium infestans* Karst.; incl. *Neonaumovia tianshanica* Shvarts.) Snow blight, but on *Picea schrenkiana* may cause general defoliation	Many spruce species; in North America, central Asia, and Europe
Peridermium thomsonii Berk. Needle rust	*Picea smithiana*, probably *P. spinulosa* Henr.; Himalayas
Pucciniastrum americanum (Farl.) Arth. Needle rust. Alternates to *Rubus*	*Picea engelmannii*, *P. glauca*; U.S.A., Canada
Rhizosphaera kalkoffii Bub. Needle cast. Although said to be a secondary pest, appears to cause loss of needles in damaging (or at least disfiguring) amounts	*Picea pungens*, *P. sitchensis*, and at least seven other species; Britain, Scandinavia, Netherlands, Germany, eastern Canada, and U.S.A.; said to be spreading in central Europe

CONE DISEASES

Parasites of spruce cones have seldom been regarded as important, even though rusts occasionally destroy more than 50 percent of a local cone crop and loss estimates as high as 80 and 90 percent have been made. Little is known of the degree of parasitism of imperfect fungi on spruce cones. *Phomopsis conorum* (Sacc.) Died. [perfect stage: *Diaporthe conorum* (Desm.) Niessl. or *D. eres* Nits.] is probably parasitic in some circumstances, but more damaging to seedlings than to cones. Several rust fungi, on the other hand, destroy most or all of the seeds in infected cones. *Chrysomyxa pirolata* Wint. (alternating to *Pyrola*) is the most widespread species. Less widely distributed species (easily introduced on seed) include the following:

Causal organism and type of damage	Hosts, distribution
Chrysomyxa monesis Zill. Cone rust. Alternates to *Pyrola* (*Monesis*)	*Picea sitchensis*; western Canada, U.S.A.

Pucciniastrum americanum (Farl.) Arth. Cone rust. Alternates to *Rubus*	*Picea engelmannii*; western Canada. Widespread in North America as a needle rust
Pucciniastrum areolatum (Fr.) Otth. /*Thekopsora padi* (Schm. & Kunze) Kleb./ Cone rust. Alternates to *Prunus*. Can cause large reduction in seed crops, for instance in *Picea asperata* Mast. Frequently intercepted by plant quarantine officers in North America	Many spruce species throughout Eurasia; introduced into West Indies

DISEASES OF PICEA ABIES (P. EXCELSA)[1]

by

Kurt Lohwag[2]

Norway spruce (_Picea abies_ (L.) Karst.) is indigenous to Europe with the exception of the southern and western parts. It also occurs over large areas of Russia and Asia. In North America and Canada, this species has been widely used for forest and ornamental plantings. Except for heavy damage caused by _Fomes annosus_ (Fr.) Karst. and some loss from damping off, no devastating pathogens attack Norway spruce.

SEEDLING DISEASES

Among seedling diseases damping off is important. The fungi most frequently involved are:

- _Pythium_ spp.
- _Phytophthora cactorum_ (L. & C.) Schroet.
- _Phytophthora cinnamomi_ Rands
- _Rhizoctonia solani_ Kuehn
- _Fusarium_ spp.

These fungi also attack plants beyond the seedling stage and cause root rot. Considerable damage to seedlings is sometimes caused by the fungus _Botrytis cinerea_ Pers., particularly in an excessively humid environment. Seedlings in nurseries and outplantings at higher altitudes can be seriously damaged by the snow mold fungus, _Herpotrichia nigra_ Hartig. Its blackish-brown mycelium grows over and smothers seedlings, causing their death.

Other diseases in nurseries are:

- _Ascochyta piniperda_ Lind.
- _Phacidium infestans_ Karst.
- _Phomopsis occulta_ Trav.

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Hochschule für Bodenkultur, Vienna, Austria

Pestalozzia hartigii Tub.
Causes great damage at times.
Rosellinia aquila (Fr.) DeN.
Rosellinia quercina Hartig
Rosellinia herpotrichoides Hepting & Davidson
Rhizina undulata Fr.
Impedes the growth of saplings.
Thelephora terrestris Fr.
Thelephora laciniata Pers.
Damage caused by too close planting in seed beds.

ROOT DISEASES

As previously mentioned, the roots of saplings can be destroyed by the same fungi that cause damping off. With older plants, in addition to the roots, above ground parts of the tree may also be attacked. The three most important root diseases of Norway spruce are caused by:

Armillaria mellea (Fr.) Quél.
Fomes annosus
Polyporus schweinitzii Fr.

STEM DISEASES

Distinction must be made between cankers in the bark and cambium and heart rots which devalue the timber in the stem.

Cankers

Nectria cucurbitula (Tode) Fr.
Cucurbitaria piceae Borthw.
Also destroys the buds.
Aleurodiscus amorphus (Pers.) Rab.
Valsa kunzei Fr.
(Imp. stage Cytospora kunzei Sacc.)
In North America this fungus causes the most prevalent stem disease of Norway spruce. The most obvious symptom is the death of individual branches, usually near the base of the crown but sometimes higher up.
Dasyscypha spp.
At times associated with cankers on twigs.

Heart rots

There are several fungi causing decay of the heartwood of living Norway spruce trees. Among them are the following:

Fomes annosus

Economically, this is the most important disease of spruce.

Fomes pini (Fr.) Karst. var. abietis (Karst.) Pilát.

Fomes pinicola (Fr.) Cke.

Polyporus borealis Fr.

Polyporus resinosus Fr.

Polyporus schweinitzii Fr.

Polyporus sulphureus Fr.

FOLIAGE DISEASES

Foliage diseases seldom kill Norway spruce trees; the damage consists of a decrease in yield resulting from a reduction in the rate of growth of diseased trees. Among the most important foliage pathogens are the following:

Chrysomyxa ledi var. rhododendri (DC.) Saville

Important at high elevations where spruce grows in association with the alternate host of this needle rust, Rhododendron spp.

Chrysomyxa abietis Unger

Lophodermium macrosporum (Hart.) Rehm

Peridermium coloradense (Diet.) Arth. & Kern

Causes a conspicuous witches'-broom.

Pucciniastrum americanum (Farl.) Arth.

Rhizosphaera kalkoffii Bub.

Possibly the most common fungus on spruce needles.

Ascochyta piniperda

Listed above as a nursery disease, this fungus also damages the needles and twigs of spruce trees.

CONE DISEASES

Cone diseases of Norway spruce are relatively unimportant. They destroy the seed in infected cones but seldom are many cones attacked. The best known cone diseases are caused by:

Chrysomyxa pyrolae Rostr.

A yellow powdery rust on outer side of green cone scales

Chrysomyxa pirolata Wint.

Similar to above

Thekospora areolata (Fr.) Magn.

On young shoots as well as cones, causing distortion.

SUMMARY

Among the great number of diseases which pose a special threat to Norway spruce, the three outstanding ones are damping off in nurseries and root and heart rots caused by Armillaria mellea and Fomes annosus.

DISEASES OF THE HARD PINES[1]

by

Arthur F. Verrall[2]

Importance of the Hard Pines

Hard pines of more than 40 species constitute important segments of the coniferous forests of the northern and southern hemisphere. At least 10 species are of great economic importance.

Pinus echinata, *P. elliottii*, *P. palustris*, and *P. taeda* are the primary source of pulpwood in southern United States. These and many other species are important sources of lumber, poles, piling, and other solid wood products. *Pinus pinaster*, *P. insularis*, *P. elliottii*, and *P. palustris* furnish naval stores in Europe, the Philippines, and the United States. Several, including *P. pinaster* and *P. pinea*, are used for sand dune stabilization; and *P. insignis*, *P. roxburghii*, and *P. halepensis* are planted to rehabilitate infertile or arid sites. The seeds of *P. pinea* are marketed as a food crop.

The hard pines include species adapted to a wide variety of sites. *Pinus tropicalis* grows at sea level in Cuba; *P. contorta* extends into the Yukon Valley. *Pinus elliottii* is native to wet sites, *P. sabiniana* to poor dry sites.

Several species, in addition to *Pinus radiata* and *P. silvestris*, are extensively planted both within and beyond their natural ranges. Except for the extension of *P. merkusii* to 1° south in Sumatra, the genus *Pinus* is native to the northern hemisphere, but many American, European, and Asian species are being successfully planted in the southern hemisphere.

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1 Exclusive of *Pinus silvestris* L. and *P. radiata* D. Don. For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964.

2 Forest Service, U. S. Department of Agriculture, Southern Forest Experiment Station, New Orleans, Louisiana.

Present and Potential Disease Impact

Several pathogens are extremely important in natural stands of hard pines. Adequate regeneration of *Pinus palustris* requires control of *Scirrhia acicola*. Over wide areas *Cronartium strobilinum* severely reduces cone and seed crops. Dwarfmistletoes (*Arceuthobium*), stem rusts (*Cronartium* and *Peridermium*), and leaf fungi (*Elytroderma*, *Lophodermium*, etc.) cause important losses. None of these pathogens, however, prevent the commercial production of hard pines on favorable sites within their natural ranges. When the pines are planted off-site, even within their natural ranges, some native pathogens become more damaging. Thus, *Cronartium fusiforme* has ruined many plantations of *P. elliottii* on sites formerly occupied by *P. palustris*. Plantations on abandoned farm land are particularly susceptible to *Fomes annosus* root rot.

Because hard pines have been extensively planted as exotics, the disease potential is known under many foreign conditions. When planted in Japan, *Pinus canariensis* and *P. nigra* are very susceptible to leaf blight caused by *Cerospora pini-densiflorae* and *Pinus taeda* to *Helicobasidium mompa*. When interplanted with cassava in Brazil, *Pinus elliottii* was severely damaged by *Armillaria mellea*. *Scleroderris lagerbergii* devastates some imported pines in Sweden. Despite these experiences, some species of hard pine have been found suitable for each country where extensive plantings have been tried.

In the annotated lists of pathogens that follow, the ranges refer to the distribution of the pathogen on any host, except in a few cases where its range could not be established. In these cases the range on pine is given, followed by (on *Pinus*).

The hard pine hosts are designated throughout the remainder of this paper by the following numbers:

Pinus

1. attenuata Lemm.
2. banksiana Lamb.
3. canariensis C. Smith
4. caribaea Morelet
5. cembroides Zucc.
6. clausa (Chapm.) Vasey
7. contorta Dougl.
8. cooperi Blanco
9. coulteri D. Don
10. densiflora Sieb. & Zucc.
11. echinata Mill.
12. edulis Engelm.
13. elliottii Engelm. var. densa Little & Dorman
14. elliottii Engelm. var. elliottii
15. engelmannii Carr.
16. glabra Walt.
17. halepensis Mill.
18. insularis Endl.
19. jeffreyi Grev. & Balf.
20. khasya Royle
21. leiophylla Schiede & Deppe
22. leiophylla var. chichuahuana (Engelm.) Shaw
23. luchuensis Mayr
24. massoniana Lamb.
25. merkusii Jungh. & De Vriese
26. monophylla Torr. & Frem.
27. mugo Turra
28. var. mughus (Scop.) Zenari
29. var. pumilio (Haenke) Zenari
30. var. rostrata (Ant.) Hoopes
31. var. rotundata (Link) Hoopes
32. muricata D. Don
33. nigra Arnold
34. var. cebennensis (Godr.) Rehd.
35. var. poiretiana Schneid.
36. occidentalis Sw.
37. oocarpa Schiede
38. palustris Mill.
39. patula Schiede & Deppe
40. pinaster Ait.
41. pinea L.
42. ponderosa Laws.
43. var. arizonica (Engelm.) Shaw
44. var. scopulorum Engelm.

45. pungens Lamb.
46. resinosa Ait.
47. rigida Mill.
48. roxburghii Sarg.
49. sabiniana Dougl.
50. serotina Michx.
51. tabulaeformis Carr.
52. var. yunnanensis (Franch.) Dallimore
53. taeda L.
54. thunbergii Parl.
55. virginiana Mill.

SEEDLING DISEASES

Any of the many organisms pathogenic on seedlings probably can cause severe losses when atmospheric and edaphic conditions favor development. Good management, fungicidal sprays, and soil fumigants usually will minimize losses in nurseries. Control in natural regeneration seldom is feasible. Many pathogens listed under Foliage, Stem, and Root Diseases also attack seedlings.

Causal organism and type of damage	Hosts and where reported:
Aristadiplodia pini Shirai Damping-off	10 Japan
Botrytis cinerea Fr. Graymold blight	7, 10, 17, 42, 44, 55 Worldwide
Ceratobasidium praticolum (Kotila) Olive Damping-off	2, 7, 46 Australia, England, India, N. America
Cercospora pini-densiflorae Hori & Nambu Pine leaf blight This is the most serious disease of pine seedlings in Japan.	3, 10, 23, 24, 40, 54 Formosa, Japan
Cladosporium herbarum (Lk.) Fr. Black mold	47 Worldwide
Cylindrocladium scoparium Morg. Seedling blight	2, 33, 35, 46, 47 Asia, Australia, East Indies, Europe, New Zealand, N. America, S. Africa, S. America, Tasmania, West Indies

Diplodia natalensis P. Evans Needle blight Thought to be the imperfect stage of *Physalospora rhodina* (Berk. & Curt.) Cke. which causes dieback and root rot of many plants in tropical and temperate areas.	14, 53 China, N. America, S. Africa
Fusarium avenaceum (Fr.) Sacc. Damping-off	2 Argentina, USA
Fusarium bulbigenum var. *blasticola* (Rostr.) Wr. Damping-off	27, 30 Argentina, Europe, Formosa, N. America
Fusarium lateritium Nees Damping-off, canker, dieback	36 Worldwide
Fusarium moniliforme (Sheld.) Snyder & Hansen Damping-off	33 USA
Fusarium oxysporum Schlecht. Damping-off	17, 33, 46 Africa, Argentina, Europe, N. America
Fusarium oxysporum Schlecht. var. *aurantiacum* (Lk.) Wr. Damping-off	10, 19, 42, 54 Europe, Japan, USA
Fusarium solani (Mart.) Appel & Wr. Root rot, damping-off	33 North Temperate Zone
Fusarium sp. Damping-off, root rot	11, 14, 18, 38, 53, 55 Worldwide
Fusoma parasiticum Tub. Damping-off	2, 7, 42 Europe, USA
Helicobasidium purpureum (Tul.) Pat. Root rot	2, 7, 15, 27, 33, 42, 46 Worldwide
Herpotrichia nigra Hartig Brown felt blight	7, 27, 33 Cooler parts of Europe, N. America, Siberia

Macrophomina magnifructa (Pk.) Sacc. Root rot	17 USA
Macrophomina phaseoli (Maubl.) Ashby (Sclerotium bataticola Taub.) Root rot In conjunction with Fusarium oxysporum, causes a serious root rot in pine nurseries in USA. Soil fumigation controls it.	2, 6, 9, 10, 11, 14, 19, 32, 38, 42, 46, 53, 55 Probably worldwide
Neopeckia coulteri (Pk.) Sacc. Brown-felt blight	7, 27, 29, 42, 44 Mountains of N. America, Poland, Romania
Pellicularia filamentosa (Pat.) Rogers (Rhizoctonia solani Kuehn) Web blight, root rot, damping-off	10, 20, 27, 33, 35, 46, 53, 54 Worldwide
Pestalotia funerea Desm. Needle blight, seedling root rot	2, 3, 24, 27, 40, 42, 46, 48 Worldwide
Pestalotia hartigii Tub. Stem girdle	27 Europe, S. Africa(?), USA
Physalospora obtusa (Schw.) Cke. Seed decay	33 Australia, Europe, New Zealand, S. Africa, USA
Phytophthora cactorum (Leb. & Cohn) Schroet. Seedling blight, damping-off	2, 7, 27, 33, 42, 46 Worldwide
Phytophthora citrophthora (R. E. & E. H. Sm.) Leonian Root rot	17 Argentina, N. America
Phytophthora parasitica Dast. Canker, blight	17 Worldwide
Pythium aphanidermatum (Edson) Fitz. Damping-off	2, 18, 42 Africa, Asia, N. America

Pythium artotrogus (Mont.) d By. Damping-off	33 Europe, Hawaii, India, N. America
Pythium debaryanum Hesse Damping-off	2, 20, 24, 30, 33, 42, 46 Africa, Asia, Australia, East Indies, Europe, Hawaii, N. America, Tasmania
Pythium irregulare Buis. Damping-off	33, 46 Europe, Hawaii, S. Africa, USA
Pythium ultimum Trow. Damping-off	2, 18, 35, 46 Africa, Australia, Europe, New Zealand, N. America, Philippines, S. America
Rhizoctonia endophytica var. filicata Sak. & Vaar. Damping-off	2 Canada
Sclerotinia kitajimana Ito & Hosaka Blight	10 Japan
Thelephora fimbriata Schw. Smothering fungus	2, 42 USA
Thelephora terrestris Fr. Smothering fungus	2, 7, 30, 42 Europe, Jamaica, N. America, S. Africa
Therrya fuckelii (Rehm) Kujala Canker	46 Canada, N. Europe, USA

Nematodes

Many species of nematodes have been found associated with pine seedlings. Damage to hard pines is reported from Argentina, Canada, Germany, Holland, Japan, USA, and USSR. The pathogenic capabilities of most species on pine are imperfectly known.

Aphelenchoides fragariae (Ritz. Bos) Christie Nematode	38 Australia, Canada, Europe, Hawaii, Japan, USA, USSR, West Indies

Belonolaimus gracilis Steiner Sting nematode	14, 38 USA
Criconemoides rusticum (Micoletzky) Taylor Ring nematode	11 USA
Criconemoides xenoplax Raski Ring nematode	11, 13, 14, 38, 53, 55 USA
Helicotylenchus dihystera Cobb Spiral nematode	14, 53 USA
Helicotylenchus erythrinae (Zimmerman) Golden Spiral nematode	11, 14, 38, 53 Java, USA
Hemicycliophora vidua Raski Sheath nematode	11, 14, 38, 53, 55 USA
Hoplolaimus galeatus (Cobb) Thorne Lance nematode	11, 14, 33, 37, 38, 47, 53 Sumatra, USA
Meloidodera floridensis Chit., Han., & Ess. Root knot nematode	6, 11, 14, 33, 38, 47, 53 USA
Meloidogyne incognita var. *acrita* Chitwood Root knot nematode	10, 54 England, Israel, S. Africa, S. America, USA
Pratylenchus brachyurus (Godfrey) Filip. & Schur.-Stek. Meadow nematode	38, 53 Hawaii, Israel, S. Africa, USA, West Indies
Pratylenchus penetrans (Cobb) Filip. & Schur.-Stek. Meadow nematode	28, 33 Canada, Holland, USA
Pratylenchus zeae Graham Meadow nematode	11, 14, 38, 53 USA
Trichodorus christiei Allen Stubby root nematode	14, 38, 53 USA
Tylenchorhynchus claytoni Steiner Stylet nematode	10, 14, 38, 53, 54 Japan, USA

Xiphinema americanum Cobb Dagger nematode	11, 13, 14, 38, 53, 55 Canada, Ceylon, Europe, Guatemala, India, Israel, USA, West Indies

FOLIAGE AND CONE DISEASES

Under forest conditions, most needle pathogens are of little economic importance. A few are known to be highly damaging. Control by fungicidal sprays is feasible with nursery and ornamental plantings, but only occasionally under forest conditions. Scirrhia acicola is controlled in plantations and natural stands of Pinus palustris by prescribed burning (under carefully selected conditions) that consumes the infected needles.

Causal organism and type of damage	Hosts and where reported:
Actinothyrium marginatum Sacc. (Dothistroma pini Hulbary) Leaf spot	33, 42, 46 Britain(?), USA, Yugoslavia
Alternaria tenuis Nees Leaf & cone spot	41 Argentina, China, Europe, India, Mauritius, N. America, Tanganyika, Tripoli
Bifusella linearis (Pk.) Hoehn. Needle cast	7 USA
Bifusella striiformis Darker Leaf cast	9, 40, 49 USA
Cladosporium laricis Sacc. Needle mold	41 Italy
Coleosporium spp. The following species have been described on hard pines. They are not generally considered of economic importance. C. melampyri has recently been reported as serious on P. nigra in Yugoslavia. Alternate hosts are listed in parentheses by genera only.	Needle rusts
C. apocynaceum Cke.	14, 38, 53 (Amsonia) USA

C. asterum (Diet.) Syd. (C. solidaginsis (Schw.) Thuem.)	2, 7, 10, 11, 24, 27, 33, 38, 42, 44, 46, 47, 54, 55 (Aster, Solidago, etc.) Bermuda, China, Europe, India, Japan, N. America
C. cacaliae Orth.	27 (Adenostyles, Cacalia) Europe, Japan, Siberia
C. campanulae Lév. ex Kickx	2, 10, 33, 46, 47, 48, 54, 55 (Campanula, Campanulastrum, Specularia, Lysimachia) Asia, Europe, USA
C. crowellii Cumm.	12 (Alternate host unknown) USA
C. delicatulum Hedgc. & Long	11, 14, 33, 38, 46, 47, 50, 53 (Euthamia) USA
C. elephantopodis (Schw.) Thuem.	11, 14, 38, 47, 50, 53 (Elephantopus) S. America, USA, West Indies
C. helianthi (Schw.) Arth.	2, 11, 55 (Helianthus) USA
C. inconspicuum Hedgc. & Long	11, 38, 55 (Coreopsis) USA
C. inulae (Kunze) E. Fisch.	17, 47 (Inula) Canary Islands, Congo, Europe, India, N. Africa, Palestine
C. ipomoeae (Schw.) Burr.	11, 14, 22, 38, 47, 50, 53 (Convolvulus, Ipomoea, etc.) Central America, S. America, USA
C. jonesii (Pk.) Arth.	5, 12 (Grossularia, Ribes) USA

C. laciniariae Arth.	38, 47, 53 (*Liatris*) USA
C. madiae (Syd.) Arth.	19 (*Anisocarpus*, *Centromadia*, etc.) N. America
C. melampyri (Reb.) Karst.	27 (*Melampyrum*) Asia, Europe
C. minutum Hedgc. & Hunt	16, 53 (*Forestiera*) USA
C. petasitis Lév.	33 (*Petasites*) Europe, Japan, Siberia
C. pinicola (Arth.) Arth.	2, 47, 55 (No alternate host. Telia on pine) Canada, Siberia, USA
C. senecionis Fr. ex Kickx	17, 18, 27, 33, 35, 40 (*Senecio*) N. Temperate Zone, S. America
C. sonchi (Strauss) Lév. ex Tul.	2 (*Sonchus*) Europe, USA, West Indies
C. terebinthinaceae Arth.	11, 38, 47, 50, 53, 55 (*Parthenium*, *Silphium*) USA
C. tussilaginis (Pers.) Lév.	33 (*Tussilago*, *Campanula*, etc.) Europe
C. vernoniae Berk. & Curt.	7, 11, 14, 16, 27, 33, 38, 47, 50, 53 (*Vernonia*) Columbia, USA, West Indies
Coryneum cinereum Dearn. Needle spot	7 USA
Cronartium conigenum Hedgc. & Hunt Cone rust	21, 22, 37 (*Quercus*) Central America, USA

Cronartium strobilinum Hedgc. & Hahn Cone rust Causes severe loss of cones in live oak belt of USA unless fungicidal sprays are used.	13, 14, 38 (Quercus virginiana) Cuba, USA
Dothichiza pithyophila (Cda.) Petr. Leaf blight	33 Europe, USA
Elytroderma deformans (Weir) Darker Needle cast Causes a serious needle cast of ponderosa pine. It penetrates and deforms the twig phloem and buds, from which it spreads to succeeding crops of leaves.	2, 5, 7, 11, 12, 19, 42, 44 Canada, USA
Hemiphacidium convexum (Dearn.) Korf Snow blight	47 USA
Hemiphacidium planum (Davis) Korf Needle blight	12, 42 USA
Hendersonia montana Vuill. Needle cast	27 France
Hendersonia pinicola Wehn. Leaf cast	7 USA
Hypoderma desmazierii Duby Needle cast	2, 33, 46, 47 Asia, Europe, N. America
Hypoderma hedgcockii Dearn. Needle cast	6, 11, 14, 38, 47, 55 USA
Hypoderma lethale Dearn. Needle cast Causes needle browning and early defoliation of P. taeda over extensive areas. The effect on tree growth may not be great because most needle death occurs after the growing season. Control in the forest is not feasible.	6, 11, 14, 33, 45, 46, 47, 50, 53, 55 USA
Hypoderma mexicanum Wolf Needle cast	21 Mexico

Hypoderma pedatum Darker Needle cast	7, 42 USA
Hypoderma pini (Dearn.) Darker Needle cast	26 USA
Hypoderma saccatum Darker Needle cast	5, 12 USA
Hypodermella ampla (J. J. Davis) Dearn. Needle cast	2 New Zealand, N. America
Hypodermella cerina Darker Needle cast	7, 42 USA
Hypodermella concolor (Dearn.) Darker Needle cast	2, 7 N. America
Hypodermella lacrimiformis Darker Needle cast	1 USA
Hypodermella medusa Dearn. Needle cast	2, 7, 19, 42, 43 N. America
Hypodermella montana Darker Leaf cast	7 Canada, USA
Hypodermella montivaga (Petr.) Dearn. Leaf cast	7 N. America
Hypodermella sulcigena (Rostr.) Tub. Leaf cast A destructive European parasite.	17, 27, 30, 33 Europe
Lembosia acicola (Harkn.) Sacc. Black mildew	49 USA
Leptothyrium pinastri Karst. Needle cast	2, 33, 46, 47 N. America, Poland
Lophodermium nitens Darker Needle cast	17, 27 Europe, N. America

Lophodermium pinastri (Fr.) Chev. Needle cast In some areas this parasite causes severe defoliation and requires constant control, particularly in nurseries; in other areas it is considered primarily a saprophyte. Possibly physiologic forms occur.	1, 2, 7, 10, 11, 14, 16, 17, 19, 21, 27, 30, 31, 33, 34, 35, 36, 40, 42, 46, 47, 48, 49, 53, 54, 55 N. Hemisphere
Mycosphaerella pinifolia Ducom. Needle blight	40 France
Naemacyclus niveus (Fr.) Sacc. Needle cast	2, 7, 17, 19, 27, 33, 35, 40, 41, 42 Central Africa, Europe, New Zealand, N. Africa, N. America
Peridermium floridanum Hedgc. & Hunt Needle rust	38 USA
Peridermium guatemalense Arth. & Kern Needle rust	38 Central America, USA
Peridermium montezumae Cumm. Pine needle rust	37 Guatemala, Honduras
Peridermium orientale Cke. Needle rust	48 India
Peridermium pini-thunbergii Diet. Pine leaf rust	54 Japan
Peridermium praelongum Syd. Needle rust	54 Japan
Peridermium weirii Arth. Needle rust	7 USA
Phacidium infestans Karst. Snow blight A low-temperature organism that attacks snow-covered needles, causing premature death.	30, 33, 42 Asia, Europe, N. America

Rhizosphaera kalkhoffii Bub. Mottled leaf cast	27, 33 Canada, Europe, USA
Scirrhia acicola (Dearn.) Siggers Brown spot The most serious pathogen of *P. palustris* in its natural range. Because of the wide host range it poses a threat to pines in other areas. Controllable by prescribed burning and fungicides.	1, 7, 9, 11, 14, 15, 16, 17, 19, 32, 33, 35, 38, 40, 41, 42, 44, 47, 49, 50, 53, 54, 55 Austria, Spain, USA
Septoria pisi Berk. Leaf spot	48 India
Sphaeropsis necatrix Petri & Adani Cone blight	41 Italy
Stilbospora pinicola Berk. & Curt. Needle blight	7 USA
Thyriopsis halepensis Theis. Leaf spot, dieback	17 Europe
Virus, Mosaic Conifer mosaic	29 Czechoslovakia

ROOT DISEASES

Several root rot fungi are important, particularly in plantations. Frequently, control in the forest is impractical. Under some circumstances control has been practiced; examples are avoidance of planting susceptible pines around fresh stumps susceptible to *Armillaria*; fungicidal treatment of stumps and soil fumigation (*Fomes annosus*); limiting thinning as much as feasible (*F. annosus*); trenching (*Poria weirii*); and choosing resistant species (*Phymatotrichum omnivorum*). Also see Seedling Diseases.

Causal organism and type of damage	Hosts and where reported:
Armillaria mellea (Fr.) Quél. Shoestring root rot	2, 4, 7, 10, 11, 13, 17, 19, 20, 27, 32, 33, 35, 36, 38, 39, 40, 42, 46, 47, 48, 51, 53 Worldwide

Armillaria sp. Root rot	25 Sumatra
Clitocybe tabescens (Fr.) Bres. Root rot	6, 13, 14, 16, 38, 53 Asia, Central America, Europe, Madagascar, N. America, Nyasaland
Flammula alnicola (Fr.) Kummer Yellow stringy root and butt rot	2, 7 Canada
Fomes annosus (Fr.) Karst. Annosus root rot One of the most important root rots of coniferous forest trees. Usually attack is most severe following harvest cuts, particularly in plantations on land formerly under cultivation.	2, 7, 10, 11, 14, 16, 27, 33, 38, 40, 41, 44, 46, 47, 48, 53, 55 N. Temperate Zone and a few tropical and subtropical places.
Fomes noxius Corner Root rot Under study in Fiji as a likely cause of root rot.	14 Africa, Central America, Cuba, East Indies, Fiji, India, Puerto Rico, USA
Ganoderma colossus (Fr.) Baker Root and collar rot	4 S. Africa (on *Pinus*)
Ganoderma lucidum (Fr.) Karst. Spongy root and butt rot	48 Worldwide
Helicobasidium compactum Boed. Root rot	48 East Indies, El Salvador, S. Africa
Helicobasidium mompa Tanaka Violet root rot In Japan, this important soil-borne pathogen attacks over 30 genera of angiosperms and 3 of conifers. Kills fine roots and, if severe, the cambium of larger roots causing decline and death of tree. Can live saprophytically in soil. No effective control known.	10, 53 China, Formosa, Japan, Java, probably Korea

Peniophora sacrata G. H. Cunn. Root and collar rot	7, 14, 35, 38, 39, 40, 53 New Zealand
Phymatotrichum omnivorum (Shear) Dug. Texas root rot This dangerous soil-borne pathogen attacks more than 100 genera of trees and shrubs in addition to many agricultural crops.	33, 42, 53 N. Mexico, Southwest USA
Phytophthora cactorum (Leb. & Cohn) Schroet. Associated with *P. cinnamomi* in New Zealand.	
Phytophthora cinnamomi Rands Root and crown rot Associated with littleleaf in USA and a similar disease in New Zealand. Losses in pole-sized stands often are heavy.	3, 11, 14, 16, 28, 32, 38, 40, 46, 47, 53, 55 Worldwide
Polyporus orientalis Lloyd Root rot	10 Japan
Polyporus schweinitzii Fr. Root and butt rot	2, 7, 10, 15, 19, 22, 26, 27, 38, 40, 41, 42, 43, 46, 48, 53, 55 Australia, New Zealand, N. Temperate Zone
Polyporus tomentosus Fr. var. *circinatus* (Fr.) Sartory & Maire (*P. circinatus* Fr.) Root and butt rot	2, 7, 13, 44, 46, 47 Europe, India, N. America
Poria cocos Wolf Root tumor	42 N. America
Poria weirii Murr. Poria root rot	42 Japan, N. America
Rhizina undulata Fr. (*R. inflata* (Schaeff.) Karst.) Group dying, seedling blight	2, 7, 27, 33, 40, 42, 46, 47 Europe, N. America

Rhizoctonia lamellifera Small Root rot	11, 32, 40 S. Africa, Uganda
Rosellinia aquila (Fr.) de N. Root rot	27 Bermuda, Central America, Europe, Japan, N. America
Rosellinia radiciperda Mass. Root rot	39 New Zealand
Verticicladiella sp. Root stain	12, 19, 26, 42 USA

STEM DISEASES

Cankers and Diebacks

Most of the fungi that attack tree stems are weak parasites causing diebacks and branch cankers or occasionally stem cankers. Under some conditions any may cause important losses, particularly to exotics. Other important canker fungi are listed under Rusts. Several fungi included under Seedling Diseases also cause diebacks. Under forest conditions the only feasible control is removal of infected trees or branches.

Causal organism and type of damage	Hosts and where reported:
Ascochyta piniperda Lindau Shoot blight	7 Europe, USA
Atropellis apiculata Lohman, Cash, & Davidson Twig canker	55 USA
Atropellis arizonica Lohman & Cash Canker	42 USA
Atropellis pinicola Zeller & Goodding Branch canker	7 USA
Atropellis piniphila (Weir) Lohman & Cash Canker Multiple stem cankers may cause considerable log degrade in Pinus contorta.	2, 7, 19, 42, 53, 55 N. America

Atropellis tingens Lohman & Cash Twig canker	2, 6, 10, 11, 14, 33, 40, 45, 46, 47, 50, 53, 55 USA
Bacillus vuilemini Trev. Pine gall	17 Belgium Spain
Brunchorstia pini Allesch. Dieback	17, 33, 40 Austria, Turkey
Caliciopsis pinea Pk. Pine canker	11, 29, 45, 47, 55 Germany, N. America
Cenangium atropurpureum Cash & Davidson Twig canker	14, 27, 33, 45, 46, 47, 53, 55 Canada, USA
Cenangium ferruginosum Fr. (C. abietis (Fr.) Rehm) Pine dieback Usually a saprophyte but occasionally wreaks heavy damage to Pinus nigra in Austria and is considered potentially dangerous.	1, 7, 10, 11, 19, 27, 30, 33, 35, 42, 46, 47, 49, 53, 54, 55 Europe, Japan, N. America
Chilonectria cucurbitula (Curr.) Sacc. Burn-blight	2, 46 USA
Crumenula pinicola (Fr.) Karst. Dieback	7, 27, 30, 33, 35 Europe, USA(?)
Crumenula sororia Karst. Dieback	33, 35 Finland, Netherlands, USSR
Cytosporella damnosa Petri Dieback	40 Italy
Dasyscyphus calyciformis (Willd.) Rehm Canker	2, 7, 29, 33, 35, 42 Europe, Japan, New Zealand, N. America, Siberia
Dasyscyphus ellisianus (Rehm) Sacc. Canker	2, 11, 14, 19, 33, 35, 38, 42, 45, 46, 47, 53, 55 USA
Dasyscyphus oblongosporus Hahn & Ayers Canker	45, 55 USA

Dasyscyphus pini (Brunch.) Hahn & Ayers Canker	7, 33 Finland, N. America, Norway, Sweden
Dasyscyphus resinarius (Cke. & Phill.) Rehm Canker	7 Europe, N. America
Dasyscyphus subtilissimus (Cke.) Sacc. Canker	7, 10, 27, 30, 33, 54 Europe, USA
Diplodia pinea (Desm.) Kickx (Sphaeropsis ellissii Sacc.) Dieback As a facultative parasite has caused serious losses in plantations of exotics in Brazil, Central and South Africa, Australia, and New Zealand. Also associated with Gloeotulasnella pinicola (Bres.) Rogers and Ceratocystis ips (Rumbold) Hunt in dry face of turpentined pines in USA.	3, 5, 7, 9, 10, 12, 14, 17, 27, 28, 32, 33, 35, 38, 39, 40, 41, 42, 46, 47, 48, 49, 53, 55 Worldwide
Excipulina pinea (Karst.) Hoehn. Dieback	7, 27, 33 Europe
Fusarium lateritium Nees f. pini Hepting Pitch canker	11, 14, 36, 38, 45, 47, 48 USA
Monochaetia unicornis (Cke.) & Ell.) Sacc. Cypress canker	14 Australia, Kenya, New Zealand, S. Africa, Tanganyika, USA
Nectria cucurbitula Fr. Dieback	2, 27, 46, 47, 53 Europe, N. America
Phacidiopycnis pseudotsugae (M. Wils.) Hahn (Phomopsis pseudotsugae Wil. & P. strobi Syd.) Canker	3, 27, 32, 33, 42 Europe, New Zealand, USA

Physalospora abdita (Berk. & Curt.) N. E. Stevens Canker	4 Australia, China, India, N. America, S. Africa
Physalospora obtusa (Schw.) Cke. Canker	33, 55 Australia, Europe, New Zealand, N. America, S. Africa
Pullularia pullulans (d By.) Berkh. Forking, dieback	7, 35, 39, 46 Worldwide
Scleroderris abietina (Lager.) Gremmen (Brunchorstia pinea (Karst.) V. Hoehn.) Dieback	7, 27, 30, 33, 35, 40, 46, 49 Europe
Scleroderris lagerbergii (Lagerb.) Gremmen Top canker On Pinus, kills shoots and buds. Damage severe in Sweden on introduced pines.	7, 33 Europe
Sclerotinia libertiana Fuckel Dieback	10 Japan
Sirex fungus (possibly a Peniophora) Pine wilt This unidentified fungus is usually considered a weak parasite. It is inoculated into living trees by the wood wasp (Sirex noctilio F.) during oviposition. Trees weakened by drought, suppression, etc., may die as a result of a few infection foci; healthy trees require mass infections. The fungus attacks and kills the cambium. In Europe, the fungus is of little consequence.	7, 11, 14, 32, 33, 35, 38, 39, 40, 42, 53 Australia, Europe, New Zealand
Trichoscyphella resinaria (Cke. & Phill.) Dennis Conifer canker	33 Great Britain, Hungary N. America, Norway

Tympanis confusa Nyl. Canker	46 USA
Tympanis hypopodia Nyl. In heartwood of living trees Thirteen other fungi also associated.	7 Canada
Tympanis sp. Canker	10, 46, 55 USA
Valsa pini Alb. & Schw. ex Fr. Canker	53, 55 USA
Valsa superficialis Nits. Branch canker	2 USA

Heart rots

Under this heading are included not only the true heart rots but the sap rots and stains reported on living trees. All are important, because they destroy or degrade the merchantable part of the tree. They enter through branch stubs or stem wounds caused by fire, harvesting equipment, and storms. Control consists of minimizing the amount of wounding and harvesting infected trees before the disease destroys their utility. Some fungi listed under Root Diseases also cause butt rot.

Causal organism and type of damage	Hosts and where reported:
Ceratocystis ips (Rumb.) C. Moreau Blue stain Associated with bark beetles in living trees. Also associated with Diplodia pinea and Gloeotulasnella pinicola in dry face of turpentined pines in USA.	10, 11, 38, 42, 46, 47, 54 Europe, Japan, N. America
Ceratocystis minor (Hedgc.) Hunt Blue stain Associated with bark beetles in living trees.	7, 10, 11, 42, 53, 54, 55 Europe, Japan, USA
Ceratocystis piceae (Münch) Bakshi Blue stain	10, 54 Europe, Japan, USA

Coniophora cerebella Pers. Heart rot	7 Europe, USA
Coryne sarcoides (Jacq.) Tul. In heartwood of living trees	2, 7, 15 England, N. America
Fomes nigrolimitatus (Rom.) Egeland Heart rot	42 Asia, Europe, New Zealand, N. America
Fomes officinalis (Fr.) Faull Brown cubical heart rot	7, 42, 44, 52 N. Temperate Zone
Fomes pini (Fr.) Karst. White pocket heart rot	2, 5, 6, 7, 11, 12, 17, 38, 42, 46, 47, 48, 53, 55 N. Hemisphere
Fomes pinicola (Fr.) Cke. Brown cubical heart rot	2, 7, 10, 15, 16, 18, 19, 20, 22, 26, 38, 40, 42, 43, 46, 47, 48, 49, 53, 55 N. Temperate Zone
Fomes roseus (Fr.) Karst. Brown cubical heart and butt rot	2, 7, 42, 43, 55 N. Hemisphere
Fomes scruposus (Fr.) G. H. Cunn. Heart rot	53 New Zealand
Fomes subroseus (Weir) Overh. Brown cubical top rot	7, 42, 43, 47 Canada, Europe(?), USA
Ganoderma applanatum (S. F. Gray) Pat. White mottled rot	48 Worldwide
Helicobasidium corticioides Bandoni Rot	7 USA
Lentinus lepideus Fr. Root and butt rot	2, 7, 19, 42 Worldwide
Lenzites saepiaria (Wulf.) Fr. Heart rot Also occurs on wood products of many species.	2 Worldwide

Merulius ambiguus Berk.	7 Canada (on Pinus)
Merulius himantioides Fr.	7 Europe, N. America
Oidiodendron fuscum Robak Blue stain in living trees	7 Canada
Peniophora luna Rom. Rot	7 Europe, USA
Peniophora pini var. duplex (Burt) Weresub & Gibson Heart rot	2, 33, 42, 46, 47, 53, 55 Canada, USA
Polyporus abietinus (Dicks.) Fr. Sap rot	7, 14, 48 Europe, India, N. America
Polyporus amorphus Fr. Trunk rot	1, 7, 11, 42, 45, 47, 53 USA
Polyporus anceps Pk. Red rot	2, 7, 42, 46, 53 Europe(?), N. America
Polyporus osseus Kalchbr. Brown butt rot	7 USA
Polyporus palustris Berk. & Curt. Brown cubical heart rot	10, 11, 48, 53 Argentina, India, Japan, USA
Polyporus sulphureus Fr. Brown cubical trunk rot	20, 42, 46 Asia, Australia, Brazil, Europe, N. America, S. Africa
Polyporus volvatus Pk. White pocket rot	42, 46, 47, 53, 55 USA
Poria monticola Murr. (P. microspora Overh.) Brown cubical rot	7, 48 Europe(?), India, N. America
Poria subacida (Pk.) Sacc. White spongy root and butt rot	7, 46, 55 Costa Rica, Japan, N. America

Stereum pini (Schleich ex Fr.) Fr. Heart rot	7 N. America
Stereum sanguinolentum Fr. Trunk rot, root rot	7, 31, 35, 42, 46, 53 Australia, New Zealand, N. Hemisphere, S. Africa
Trametes serialis Fr. Butt rot	7, 42 Europe, Mauritania, N. America, Sierra Leone

Rusts

Branch and stem rusts are among the most destructive pests of hard pines, and extreme care is needed to prevent further inter-continental spread of rusts. Pines should not be extensively planted as exotics until their resistance to local rusts has been established. Controls include eradication of infected pines or the alternate host (listed in parentheses by genera only), use of resistant species or varieties of pines, and such silvicultural practices as close planting to promote early natural pruning of infected branches.

Causal organism and type of damage	Hosts and where reported:
Cronartium appalachianum Hepting Blister rust	55 (Buckleya) USA
Cronartium coleosporioides (Diet. & Holw.) Arth. Felt rust This rust with telial stage on Castilleja, Pedicularis, Cordylanthus, Orthocarpus, and Rhinanthus includes, at least in part, Peridermium harknessii, P. filamentosum, and P. stalactiformis. Some forms (or species) can repeat on Pinus without an alternate host. See Peridermium.	
Cronartium comandrae Pk. Comandra blister rust	1, 2, 7, 11, 19, 33, 40, 42, 43, 44, 45, 46, 47, 53 (Comandra) N. America

Cronartium comptoniae Arth. Sweetfern blister rust As _Myrica gale_ is present in the Temperate Zone around the world, this rust is a potential threat to hard pines over wide areas.	2, 7, 9, 10, 11, 19, 27, 32, 33, 40, 42, 46, 47, 53, 55 (_Comptonia_, _Myrica_) N. America
Cronartium flaccidum (Alb. & Schw.) Wint. Felt rust Mainly on _P. silvestris_, but may be a threat to other hard pines.	10, 17, 27, 33, 40, 52 (_Tropaeolum_, _Vincetoxicum_, plus plants in eight other families) Asia, Europe (once reported on Prince Edward Island in N. America but apparently did not survive)
Cronartium fusiforme Hedgc. & Hunt ex Cumm. Southern fusiform rust One of the most destructive rusts in USA. Its introduction into other areas having the alternate hosts should be prevented.	4, 8, 13, 14, 33, 38, 47, 50, 53 (_Quercus_, _Castanea_, _Castanopsis_, _Lithocarpus_) USA
Cronartium himalayense Bagchee Pine-Swertia felt rust A destructive rust. Its potentiality on other pines is unknown.	48 (_Swertia_) India, Pakistan, Philippines
Cronartium occidentale Hedgc., Bethel, & Hunt Pinon blister rust	12, 26, (_Grossularia_, _Ribes_) USA
Cronartium quercuum (Berk.) Miyabe ex Shirai (Including _C. cerebrum_ (Pk.) Hedgc. & Long) Pine-oak gall rust	2, 6, 10, 11, 14, 16, 17, 20, 22, 23, 24, 33, 35, 38, 40, 42, 44, 45, 46, 47, 52, 53, 54, 55 (_Quercus_, _Castanea_) Asia, Europe(?), N. Africa(?) N. America
Melampsora albertensis Arth. Douglas-fir rust	42 Argentina, Canada, Mexico, USA

Melampsora pinitorqua (Braun) Rostr. Pine twist rust The reported occurrence in Canada now thought to be that of _M. Albertensis_ Arth. Inoculations show that this native rust will infect pine.	17, 27, 33, 35, 40, 41, 42 (_Populus_) Europe
Melampsora populnea (Pers.) Karst. Poplar rust	27 Argentina, Asia, Europe, S. Africa, USA
Peridermium filamentosum Pk. Branch rust (See _Cronartium coleosporioides_)	2, 7, 19, 27, 42, 44 Central America, N. America
Peridermium harknessii Moore Western gall rust (See _Cronartium coleisporioides_) This rust, not needing an alternate host, is a threat to hard pines on other continents.	1, 2, 3, 7, 9, 10, 14, 15, 17, 19, 27, 32, 33, 35, 42, 44, 49, 53, 54, 55 N. America
Peridermium japonicum Syd.	54 Japan
Peridermium mexicanum Arth. & Kern Gall rust	37, 39 Guatemala, Mexico
Peridermium pini (Pers.) Lév. Blister rust Spreads from pine to pine without an alternate host, and may be important if introduced to other areas. Sometimes considered a non-alternating race of _Cronartium flaccidum_.	35 Europe
Peridermium stalactiforme Arth. & Kern Stalactiform rust (canker) (See _Cronartium coleosporioides_)	2, 7, 19, 42 N. America

Mistletoes

Dwarfmistletoes of the genus *Arceuthobium* are serious pathogens of hard pines in North America. At least one North American species is known to attack an exotic pine. The other genera are of minor importance on *Pinus* but are destructive to hardwoods. Control is mainly by removal of infected trees or branches.

Causal organism and type of damage	Hosts and where reported:
Arceuthobium americanum Nutt. ex Engelm. Pine mistletoe	1, 2, 7, 12, 19, 42 N. America
Arceuthobium campylopodum Engelm. Dwarfmistletoe	32, 36 N. America
Arceuthobium campylopodum f. *campylopodum* (Engelm.) Gill Dwarfmistletoe	1, 2, 4, 7, 9, 19, 41, 42, 44, 46, 49, 55 Mexico, USA
Arceuthobium campylopodum f. *divaricatum* (Engelm.) Gill Dwarfmistletoe	12, 26 Mexico, USA
Arceuthobium campylopodum f. *laricis* (Piper) Gill Dwarfmistletoe	7, 42 N. America
Arceuthobium chinense Lec. Dwarfmistletoe	51 Asia
Arceuthobium gillii Hawksworth & Wiens Dwarfmistletoe	22 Mexico, USA
Arceuthobium pusillum Peck Spruce dwarfmistletoe	2, 46 Canada, USA
Arceuthobium vaginatum (Willd.) Presl. var. *vaginatum* Hawksworth Dwarfmistletoe	15, 21, 22, 43 Guatemala, Mexico, USA
Arceuthobium vaginatum var. *cryptopodum* (Engelm.) Gill Dwarfmistletoe	7, 42, 44 Mexico, USA
Loranthus sp. Mistletoe	32 Australia

Viscum album L. European mistletoe	2, 27, 42, 46 Asia, Europe, N. Africa

DISEASES OF PINUS SILVESTRIS[1]

by

Edwin Donaubauer[2]

Importance of the Species

The natural range of Scotch pine, Pinus silvestris L., extends from Spain through France and Northern Italy to Turkey (insular-shaped occurrences in higher sites); more extended occurrences are to be found in Central Europe, and further north, in Scotland and Scandinavia (in Finland more than 43 percent of the actual cut). In the East, Scotch pine's natural range extends over northern USSR (Russia, Siberia; of a stocked forest area of 680.9 million hectares 16.1 percent are of Scotch pine) to the vicinity of the Baikal Lake. The area of the highest rate of concentration lies in continental Eastern Europe and Northern Asia.

Scotch pine is not found in the Far North, north of the 70th degree of latitude in Scandinavia, north of the 67th parallel in European Russia or north of the 65th parallel in Siberia. The southernmost occurrences are in the zone of the 37th degree of latitude in Spain.

The great frequency of occurrences in dry zones is explained by the fact that Pinus silvestris is less susceptible to drought than other coniferous tree species, bears frost and heat relatively well and makes but modest demands on the soil. Its distribution on fertile lowland sites is limited because of competition from other species.

Pinus silvestris has been planted in many countries outside its natural range, such as the U.S.A., Canada, Japan, New Zealand, and India,--partly, however, more or less in the form of experimental plantations.

Scotch pine wood is well adapted to machining and thus has many possible uses, such as: Construction lumber (beams, square timber, building and scaffold poles, scaffold boards, building planks, floorboards, rafters), joinery-wood, ship-masts, railway crossties,

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forstliche Bundesversuchsanstalt, Oberer Tirolergarten, Vienna, Austria

piles, electric and telephone poles, posts, barrel-staves, veneer wood, box-boards, pit-props, and pulpwood.

Within the vast area of distribution of Pinus silvestris a great number of more or less varying ecotypes have developed whose peculiarities have been the subjects of detailed research during the last 50 years. In this connection it might be of special value to refer to the fact that in different provenances differing resistance or susceptibility reactions to diseases have also been observed. Particular attention should be drawn to the investigations on the resistance to Lophodermium pinicolum Tehon (L. pinastri (Schrad.) Chev.), Peridermium pini (Pers.) Lev. and Melampsora pinitorqua Rostr. The results achieved up to now in the field of resistance research and breeding are encouraging and lead us to expect that some diseases might thus be controlled.

Present and Potential Disease Impact

In the nursery, Scotch pine is likely to suffer from numerous diseases if soil conditions are unfavourable. A pH-value of about 5.5 is regarded as most favourable, but the degree of acidity often ranges in practice from 6 to 7. One of the most frequent diseases in nurseries and plantations is Lophodermium needle cast. In many areas propagation of Scotch pine is possible only if fungicides (copper and Zineb preparations) are applied.

In stands, Fomes annosus and Polyporus schweinitzii occur as the main pathogens causing wide-spread damage.

Dangerous enemies are also found among rusts in the genus Cronartium (C. flaccidum incl. Peridermium pini in Europe, C. harknessi in North America).

The danger and harmfulness of some pathogens is rated in a completely different way in some countries. This may indicate that Scotch pine shows a certain susceptibility to disease under certain macro- or micro-climatic conditions. This is quite evident in the case of Phacidium infestans Karst.: This fungus is known as a dangerous enemy of young plants at all such localities where a certain height of snow and a certain prolonged snow cover period prevail. Macrophoma sapinea is widespread but seems to become dangerous only in the southern region of occurrence of Scotch pine and then only from time to time. The position of Cenangium ferruginosum Fr. is still disputed: The fungus has been cited during the last years in connection with a pine dieback in Central and Southern Europe. This fungus seems to appear as a weak parasite after a certain sequence of weather (by itself or only along with other causes?). The examples outlined above emphasize the fact that present knowledge of the

degree of weakness of a host plant necessary for successful infection is still insufficient in the case of most pathogens; insufficient at least regarding the possible effects in case a pathogen is imported into new surroundings.

In the following list a great many pathogens are cited. Relatively few of them are of outstanding economic importance regionally and regarding the damages caused; those which are designated by xxx, meaning of great importance, dangerous; xx means of some importance, may be dangerous; while x means of no importance, not dangerous. Of some fungi the importation to other countries and, along with it, considerable damage, is to be feared. These are mainly:

Atropellis spp.
potentially dangerous for damage in Eurasia

Cenangium kazachstanicum Schwarzm.
potentially dangerous for damage in Europe and North America

Coleosporium solidaginis (Schw.) Thum.
potentially dangerous for damage in Europe

Cronartium coleosporioides (Diet. et Holw.) Arth.
potentially dangerous for damage in Eurasia

Hypodermella sulcigena (Rostr.) Tub.
potentially dangerous for damage in North America

Scleroderris lagerbergii Grem.
potentially dangerous for damage in North America

SEEDLING DISEASES

Under favourable environmental conditions for the pathogen and unfavourable cultural methods (too dense plant spacing) serious damage may occur. The choice of suitable nurseries, appropriate nursery practices and the application of modern fungicides (incl. soil fumigation) may help to prevent damage or at least reduce it to a tolerable degree.

Causal organism and type of damage	Reported from:	Importance
Alternaria tenuis Nees. Damping off; occasionally associated with shoot die-back of young conifers.	Canada, Czechoslovakia, England	xx

Alternaria sp. Damping off	Czechoslovakia	xx
Botrytis cinerea Pers. ex Fr. Grey mold; causes blight and decay of young seedlings of conifers and broad-leaved trees.	Austria, Canada, CSSR, Sweden	xx x
Discella strobilina (Desm.) Died. (*Ascochyta parasitica* (Htg.) Rostr.) On twigs; damping off of conifers.	Finland	x
Cylindrocladium scoparium Morg. Root rot	U.S.A.	x
Fusarium bulbigenum var. *blasticola* (Rostr.) Wr. Damping off	Austria, Czechoslovakia, Germany	xxx
Fusarium oxysporum Schlecht. emend. Snyder & Hansen Damping off	CSSR, Norway	xx
Fusarium oxysporum var. *aurantiacum* (Lk.) Wr. Damping off	Germany	
Fusarium oxysporum var. *redolens* (Wr.) Gordon Damping off	Canada	xx
Fusarium solani (Mart.) Appel & Wr. Root rot	CSSR, Sweden	xx
Fusarium spp. Damping off	Finland, Sweden	x
Ceratobasidium praticolum (Kotila) Olive Damping off	Canada	xxx
Helicobasidium purpureum (Tul.)Pat. Attacks the roots of a large variety of plants including trees	Germany	xx
Pestalozzia hartigii Tub. Stem girdle	Austria, Czechoclovakia, Denmark, Finland, Norway, Poland, Sweden	x

Phytophthora cactorum (Leb. & Cohn) Schroet. Damping off	Czechoslovakia, Sweden	x
Phytophthora cinnamomi Rands Root rot of seedlings	U.S.A.	xxx
Pythium aphanidermatum (Edson) Fitzp. Damping off	Canada	xxx
Pythium debaryanum Hesse Damping off	Bulgaria, Canada, England, Holland,	xxx
	Norway, Sweden	x
Pythium irregulare Buis. Damping off	Canada, England	xxx
Pythium torulosum Coker & Patterson Damping off	Holland	xx
Pythium ultimum Trow. Damping off	Canada, USA	xxx
Pythium vexans de Bary Damping off	Canada	xxx
Rhizoctonia callae Castell. Damping off and root rot	Canada	xxx
Rhizoctonia endophytica var. *endophytica* Saks. & Vaartaja Damping off and root rot	Canada	xxx
Rhizoctonia repens Bernard Damping off and root rot	Canada	xxx
Rhizoctonia rubiginosa Sappa & Mosca Damping off and root rot	Canada	xxx
Rhizoctonia solani Kuhn (*Corticium solani* (Prill. & Delacr.) Bourd. & Galz.; *Pellicularia filamentosa* (Pat.) Rogers Damping off and root rot	Belgium, Canada, England, Norway, Sweden	xxx

Thelephora terrestris (Ehr.) Fr. Smothering disease	Canada	x - xx
Thelephora caryophyllea (Schaef.) Fr. Smothering disease	Canada	x

ROOT DISEASES

These diseases are locally of great importance, but control measures are in most cases impracticable. As a preventive measure during the planting period, a proper selection of site and silvicultural measures (mixed stands) are sometimes recommended.

Causal organism and type of damage	Reported from:	Importance
Armillaria mellea (Vahl ex Fr.) Quél. Shoestring root rot. Scotch pine is highly susceptible. Occasionally causes severe losses in young plantations in old hardwood ground	Belgium, CSSR, Denmark, England, Finland, France, Germany, Japan, Ireland, Italy, Norway, Holland, Poland, Sweden, USSR	xxx xx
Clitocybe tabescens (Scop. ex Fr.) Bres. Root rot	Europe, North America	xx
Cylindrocarpon radicicola Wollenw. Root rot of seedlings and young plants.	Sweden	x
Fomes annosus (Fr.) Karst. Fomes root and butt rot; the fungus causes characteristic decay, both in the roots and in the heartwood of living trees (usually occurring on conifers but occasionally on hardwoods). Severe attacks of F. annosus have occurred in plantations which appeared to be growing under excellent conditions. This disease has attracted much attention especially in Europe, both in forest practice and research. No	Canada, Europe, India, U.S.A., USSR	xxx

effective controls are known. Silvicultural measures may lessen the loss.		
<u>Polyporus</u> <u>schweinitzii</u> Fr. Root and butt rot. In some countries it appears to be a potentially dangerous parasite, but less to be feared than either <u>Fomes</u> <u>annosus</u> or <u>Armillaria</u>. Occasionally in nurseries.	Denmark, England Finland, Germany, Norway, Poland, Sweden, U.S.A., USSR	xxx
<u>Polyporus</u> <u>tomentosus</u> Fr. var. <u>circinatus</u> (Fr.) Salory & Maire Root and heart rot	Poland	xx
<u>Rhizina</u> <u>inflata</u> (Schaff.) Karst. (<u>Rh</u>. <u>undulata</u> Fr.) Root rot Causes group dying of conifers, particularly on sites where fire has been a year or two before. It is commonest in the 20 - 30 year age range. Control: In areas where active attack of <u>Rh</u>. <u>inflata</u> is known to occur the lighting of fires in or on the margins of plantations should be avoided.	England, Finland, France, Germany, Holland, Sweden	xx
<u>Sparassis</u> <u>crispa</u> (Wulf. ex Fr.) Fr. Sparassis root rot of conifers	Denmark, Germany, Poland, Scotland,	xx
	Norway, Sweden	x

STEM DISEASES

No direct controls of the dangerous diseases mentioned below are possible in practice. Silvicultural measures are recommended. Against some diseases, improvement of resistance qualities by breeding methods is being investigated.

Cankers

Causal organism and type of damage	Reported from:	Importance:
Atropellis tingens Lohman & Cash Causes perennial canker and dieback on stems, branches and twigs of pines.	U.S.A.	xxx
Caliciopsis pinea Peck Canker on stems of suppressed saplings and on shaded branches	U.S.A.	x
Caliciopsis sp.	Canada	x
Cenangium ferruginosum Fr. Dieback of twigs and branches	Austria, Czechoslovakia, England, Germany, Jugoslavia, Poland, Denmark	xx
	Finland, Sweden, U.S.A.	x
Cenangium kazachstanicum Schwarzm. Dieback	USSR	xx
Crumenula pinicola Karst. Dieback	Denmark, France, Germany, Holland, Norway, Sweden	xx
Crumenula sororia Karst. Dieback	Denmark, Holland,	x
	Finland, Sweden	xx
Cucurbidothis pithyophila (Fr.) Petr. Cankers, swelling and dieback	Denmark, England, Finland, Germany, Norway	x
Cytospora curreyi Sacc. Canker on branches	Great Britain	xx
Dasyscypha calyciformis (Willd.) Rehm Canker	Belgium, Denmark Estonia, Sweden	xx
	Norway	x

Dasyscypha ellisiana (Rehm) Sacc. Canker	U.S.A.	xx
Dasyscypha pini (Brunch.) Hahn & Ayers (D. fuscosanguinea Auct. non Rahm) Canker; dying of young trees and dying of top of older trees	Finland, Norway, Sweden	xx
Dasyscypha subtilissima (Cke.) Sacc. Stem canker	Finland, Norway, Scotland, Sweden	xx
Dasyscypha resinaria (Cke. & Phill.) Rehm Bark canker	Norway, Sweden	xx (x)
Macrophoma sapinea (Fr.) Petr. (Diplodia pinea (Desm.) Kickx.) Canker and twig blight. Occasionally severe in the southern Scotch pine area	Argentina, Austria, France, Great Britain, Holland, Japan, Rumania	xx
Nectria cinnabarina (Tode ex Fr.) Fr. Bark canker	Finland	x
Phacidiella coniferarum Hahn (Imp. stage: Phacidiopynis pseudotsugae (Wils.) Hahn; Phomopsis pseudotsugae Wils.) Twig canker and dieback	Holland	x
Phomopsis occulta (Sacc.) Trav. Twig canker and dieback	Great Britain Japan	x
Scleroderris lagerbergii Gremmen Dieback of shoots and branches	Belgium, Denmark, England, Finland, Holland, Hungary, Norway, Russia, Spain, Sweden, Switzerland	xxx
Scoleconectria cucurbitula (Tode ex Fr.) Booth Dieback	Finland, Norway, Sweden	x

Sclerophoma magnusiana Wils. & Hahn (S. pithya (Sacc.) Died.) Girdling	Finland, Sweden	x
Valsa pini Alb. & Schw. ex Fr. On twigs (Saprophyte ?)	Canada (Holland)	(x)

Rusts

Causal organism and type of damage	Reported from:	Importance:
Cronartium cerebrum Hedge. & Long American pine-oak gall rust (See C. quercuum)	Canada, U.S.A.	xxx
Cronartium coleosporioides (Diet. et Holw.) Arth. "Woodgate rust" (Cronartium harknessii (Moore) Meinecke) Western globoid stem gall	Canada, U.S.A.	xxx
Cronartium comandrae Peck Comandra blister rust	Canada, U.S.A.	xxx
Cronartium comptoniae Arth. Sweetfern blister rust	Canada, U.S.A.	xx-xxx
Cronartium flaccidum (Alb. & Schw.) (incl. Peridermium pini (Pers.) Lev.) Causes swellings; the fungus girdles branches, occasionally the main stem.	Austria, Belgium, Bulgaria, CSSR, Denmark, England, Finland, France, Germany, Ireland, Norway, Poland, Sweden, Switzerland, USSR	xxx
Cronartium gentianeum Thum. (May be only a race of C. flacc.)	Switzerland	xx
Cronartium quercuum (Berk.) Miyabe Asian pine-oak blister rust. The taxonomy is uncertain (id. with C. cerebrum ?)	Japan, USSR	xxx

Melampsora pinitorqua Rostr. Pine twisting rust. Damages young pines in nurseries and plantations	Austria, Belgium, Denmark, England, Finland, France, Germany, Italy, Jugoslavia, Norway, Poland, Sweden, Switzerland, Russia	xxx

Heart Rots (incl. Fungal Stains)

Causal organism and type of damage	Reported from:	Importance:
Ale[illegible]odiscus penicillatus Burt.	Canada	x
Ceratocystis coerulescens (Münch) Bakshi Sap stain	Europe, North America	xx
Ceratocystis ips (Rumb.) Moreau Sap stain	Europe, Japan, North America	xx
Ceratocystis minor (Hedge.) Hunt. Sap stain	Europe, Japan, North America	xx
Ceratocystis piceae (Münch) Bakshi Sap stain	Europe, Japan, North America	xx
Ceratocystis pilifera (Fr.) Moreau Sap stain	Europe, Japan, North America	xx
Coniophora bourdotii Bres. Butt rot	Sweden	x
Coniophora puteana (Fr.) Karst. Butt rot	Sweden	xx
Exidia umbrinella Bres. Trunk rot	Germany	x
Fomes marginatus (Pers. ex Fr.) Fr. (Fomes pinicola (Sw. ex Fr.) Cke.) Wound rot of living tree trunks and timber (conifers and hardwoods). (On pines, rot of sapwood)	Central Europe, Denmark, England, Finland, Norway, Sweden, Canada	x-xx xxx

Ganoderma applanatum (Pers.) Pat. White mottled rot	Canada	x
Lentinus lepideus (Fr. ex Fr.)Fr. Heart rot; occasionally wound parasite	Germany	x
Polyporus abietinus Fr. Purple conk; "Pitted sap rot." Seldom as wound parasite	Canada, Germany	x
Polyporus giganteus (Pers.) ex Fr. White rot; occasionally on dying conifers	Sweden	x
Polyporus resinosus Fr. Trunk rot; saprophytic, sometimes wound parasite on hardwoods and conifers	Denmark	x
Polyporus schweinitzii Fr. See root rots.		
Polyporus sulphureus (Bull.) ex Fr. Brown heart rot	England	xx
Poria vaporaria Fr. Trunk rot	Germany, Sweden	x
Sparassis crispa (Wulf. ex Fr.) Fr. Root and butt rot. See root diseases	Denmark, Germany, Norway, Poland, Scotland, Sweden	
Stereum pini (Schleich ex Fr.) Fr. Brown rot of branches and trunks	Denmark, Finland, Sweden	x
Stereum sanguinolentum (Alb. & Schw.) Fr. Widespread on coniferous slash, causing serious decay in living trees in Scandinavia	Denmark Finland Norway, Sweden	x xx xxx

<u>Trametes</u> <u>odorata</u> (Wulf. ex Fr.) Fr. Brown rot	Denmark	x
<u>Trametes</u> <u>pini</u> (Brot. ex Fr.) Fr. (<u>Fomes</u> <u>pini</u> (Broth. ex Fr.) Karst.) Heart rot. White pocket rot. In Germany, serious in regions where the rainfall is less than 600 mm.	Austria, Belgium, CSSR, Denmark, Finland, Germany, Great Britain, Norway, Poland, Russia, Siberia, Sweden, USA	xx

<u>Mistletoes:</u>

<u>Causal organism and type of damage</u>	<u>Reported from:</u>	<u>Importance:</u>
<u>Viscum</u> <u>album</u> L. European mistletoe	Austria, Czechoslovakia, France, Germany, Poland, Russia	xx-xxx

DISEASES OF CONES

<u>Causal organism and type of damage</u>	<u>Reported from:</u>	<u>Importance:</u>
<u>Phoma</u> <u>strobiligena</u> Desm. Necrotic spots on green cones	Great Britain	xx

FOLIAGE DISEASES

Dangerous needle diseases are recorded for Scotch pine only in young plants. They can be controlled in the nursery or plantation by modern fungicides. Here, too, resistance research is in progress.

<u>Causal organism and type of damage</u>	<u>Reported from:</u>	<u>Importance:</u>
<u>Cytospora</u> <u>pinastri</u> Fr.	Austria	x
<u>Hendersonia</u> <u>acicola</u> Tub. Needle cast	Denmark, Finland, Great Britain, Sweden	x
<u>Herpotrichia</u> <u>juniperi</u> (Duby) Petr. (<u>H.</u> <u>nigra</u> Htg.) Conifer brown felt blight. Found particularly on small snow-covered plants in the nursery	Austria, Switzerland, Norway	xx

Herpotrichia-like mycelium	Finland, Norway, Sweden	xx
Hypoderma desmazierii Duby Needle cast	Canada, Germany	x
Hypodermella conjuncta Dark. Needle cast (id. with. H. desmazierii ?)	Scotland	xx
Hypodermella sulcigena (Rostr.) Tub. Needle cast	Czechoslovakia England, Finland, Germany, Norway, Scotland Denmark, Sweden	xx x
Lophodermium pinicolum Tehon (L. pinastri Schrad. ex Fr.) Chev.) Needle cast; particularly in nurseries and young plantations	Austria, Belgium, CSSR, Denmark, England, Germany, Finland, France, Japan, (xx) Hungary, Ireland, Norway, Poland, Russia, Sweden, Switzerland, USA, Canada	xxx x
Naemacyclus niveus (Pers. ex Fr.) Sacc. Needle cast	Austria, England France, Scotland, USA	x-xx
Pestalozzia funerea Desm.	USA	x
Phacidium infestans Karst. Snow blight. In nurseries and young plantations. (Provenance resistance is known)	Finland, Norway, Sweden, Russia	xxx
Phacidium lacerum Fr.	Holland	(x)
Scirrhia acicola (Dearn.) Siggers Leaf spot. The imperfect stage Lecanosticta acicola (Thum.) Syd. is reported from Austria on P. nigra and from Spain on P. halepensis, P. pinaster, P. radiata and P. silvestris	USA	xx
Sclerophoma pithyophila (Corda) v. Hohn	Finland, Norway, Sweden	x

Septoria acuum Oud. Pine needle spot	Great Britain	xx
Rusts		
Coleosporium campanulae (Pers.) Lév.	Eurasia, North America	x
Coleosporium clematidis Barcl.	Japan	x
Coleosporium euphrasiae (Schum.) Wint.	Eurasia	(x)
Coleosporium inulae Rab.	Eurasia	(x)
Coleosporium melampyri Tul.	Finland, Germany (Eurasia)	(x)
Coleosporium petasitis Lév.	Eurasia	(x)
Coleosporium phellodendri Kom.	Japan	x
Coleosporium pulsatillae (Straub) Lév.	Eurasia	x
Coleosporium senecionis (Pers.) Fr. (C. cacaliae (De Candolle) Otth.)	Belgium, Denmark Estonia, France, Germany, Great Britain, Ireland, Sweden (Eurasia, America)	x
Coleosporium solidaginis (Schw.) Thum. (C. asterum (Diet.) Syd.)	Japan, USA	xxx
Coleosporium sonchi (Schum.) Lév.	Estonia, Germany, Great Britain, Switzerland, USA (North America, Eurasia)	x
Coleosporium tussilaginis (Pers.) Lév.	Denmark, Estonia, Finland, Germany, Great Britain, Norway	xx
	Sweden (Eurasia)	x

DISEASES OF WHITE (5-NEEDLE) PINES[1]

by

Thomas S. Buchanan[2]

Worldwide there are more than twenty-five species of white pines, mostly with 5 needles. The fifteen species of significance as forest and timber trees are listed below with their natural ranges.

(1) Pinus albicaulis Engelm. Mountains from southwestern Alberta and central British Columbia (Canada) to Washington, Oregon, central California, Nevada, and western Wyoming (USA)	whitebark pine
(2) Pinus aristata Engelm. High mountains from Colorado to eastern California, northern Arizona, and northern New Mexico (USA)	bristlecone pine
(3) Pinus armandii Franch. China, Taiwan, and Korea	Armand pine
(4) Pinus ayacahuite Ehrenb. Mountains of Mexico and Guatemala	Mexican white pine
(5) Pinus balfouriana Grev. & Balf. High mountains of California (USA)	foxtail pine
(6) Pinus cembra L. (including varieties sibirica Mayr and pumila Pallas) Alps at 5-8,000 feet; from northern USSR through northern Asia to Japan	Swiss stone pine
(7) Pinus flexilis James (P. flexilis var. flexilis) Southern Alberta and southeastern British Columbia (Canada) and south in Rocky Mountain region to southern California and New Mexico (USA)	limber pine

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forest Service, U.S. Department of Agriculture, Washington, D.C.

(8) Pinus griffithii McClell. — Bhutan (blue) pine
(P. excelsa Wall.)
(P. wallichiana A. B. Jacks.)
Temperate regions of Himalayas from Nepal through India and Pakistan to Afghanistan

(9) Pinus koraiensis Sieb. & Zucc. — Korean pine
Northeastern Asia from southern Siberia through Manchuria to Korea and central Japan

(10) Pinus lambertiana Dougl. — sugar pine
Western Oregon and through California (USA) to northern Baja California (Mexico)

(11) Pinus monticola Dougl. — western white pine
Coast and interior southern British Columbia (Canada) to western Montana, northern Idaho, Washington, western Oregon, central California, and western Nevada (USA)

(12) Pinus parviflora Siev. & Zucc. — Japanese white pine
(including P. pentaphylla Mayr)
Higher elevations in Japan

(13) Pinus peuce Griseb. — Balkan (Macedonian) pine
Balkan Mountains; Bulgaria, Macedonia, Montenegro

(14) Pinus strobiformis Engelm. — southwestern white pine
(P. flexilis var. reflexa Engelm.)
Mountains of southwestern Texas, southern New Mexico and Arizona (USA) and northern Mexico

(15) Pinus strobus L. — eastern white pine
Newfoundland and St. Lawrence Basin to southeastern Manitoba (Canada), the Lake States, throughout the northeast and southward in Pennsylvania and the southern Appalachians to north Georgia (USA). Also a variety (chiapensis Martinez) in southern Mexico and Guatemala.

Importance of the Group

Of the nine species native to North America, Pinus strobus, P. lambertiana, and P. monticola are commercially important in the United States; P. strobus and P. monticola in Canada; and P. ayacahuite and P. strobiformis in Mexico. In 1948 there were 878 million board feet of eastern white pine, 151 million board feet of western white pine, and 117 million board feet of sugar pine used in the manufacture of wood products in the United States alone. Of the six European and Asiatic species, Pinus cembra (var. sibirica) is economically important at lower elevations in Siberia and products therefrom are export items; P. griffithii is of importance in India and Pakistan, and P. peuce is a valued timber tree in the Balkans. The white pines are distributed naturally around the world but confined primarily to the North Temperate Zone; exceptions are P. ayacahuite and P. strobus in Mexico and Guatemala, and possibly P. armandii in Taiwan, but even there these species, except for P. strobus, are found only at higher elevations under essentially temperate climatic conditions.

The commercially important white pines are tall, straight-stemmed trees attaining sufficient size to produce valuable saw- and veneer-logs. Sugar pine is the largest of the group, sometimes reaching 200 feet in height and 6 to 8 feet in diameter; individual old-growth eastern and western white pines occasionally approach these dimensions. The wood of white pines is characteristically light in weight and color, straight-grained, slightly resinous with a pleasant aroma, soft and easily worked by hand or machine, and moderately resistant to decay when in use.

The available sizes and inherent qualities create a demand for white pine wood for pattern stock, interior woodwork, exterior siding and trim, cabinet making, woodenware, matches, and other specialized uses. In earlier times, eastern white pine was in great demand for ship masts. Poorer grades of white pine are used locally for general construction and fuel wood.

In addition to their values as timber trees, Pinus griffithii, the most important timber tree in the Himalayas excepting Cedrus deodara (Roxb.) Loud. and Pinus roxburghii Sarg., are tapped in India for resin and P. armandii provides an east Asian source of edible seeds. Pinus cembra var. sibirica is a source of both resin and nuts in the Soviet Union. Even the less valuable species often have high esthetic appeal in their natural habitats and hence are also used for ornamental purposes where climatic conditions permit.

The white pines have been widely introduced into countries outside their native ranges. Eastern white pine, however, is the only North American species planted in Europe (more than 20 countries recorded) for commercial forestry purposes. This species is known to have been

introduced into England as early as 1705. In Austria, almost 10 percent of the forested area or over 750,000 acres is composed of this introduction. All other introductions from North America have been largely for ornamental or experimental purposes and a few specimen trees are to be found in various arboreta. The native species Pinus cembra and P. peuce are next in importance in European forestry. Pinus griffithii also has good growth prospects and, like P. cembra and P. peuce, possesses more or less resistance to white pine blister rust.

Present and Potential Disease Impact

One disease, white pine blister rust, already has had tremendous impact on the economic utility of white pines, both in their native habitats and in lands where they have been introduced. With the possible exception of chestnut blight, no single forest tree disease has caused so much destruction and damage. While blister rust may not threaten the elimination of a species, as the blight has essentially done to the chestnut in North America, it has tremendously increased the cost of growing white pine in nearly all areas, has prevented more extensive use of representative species as exotics, and has led to the substitution of less desirable species.

White pine blister rust is the classic example of a forest tree disease relatively innocuous in its native land (Siberia) and on its native host (Pinus cembra), but causing untold destruction when introduced to new hosts in new environments. Because eastern white pine was (is) such a desirable species, it was one of the first to be introduced into many lands as an exotic. Unfortunately, the blister rust pathogen was moved along with it until white pine blister rust is to be found almost everywhere white pines and ribes are growing in association.

Examination of table I will show that white pine blister rust has been recorded in more different countries on eastern white pine than on any other species. This is because of the widespread introductions of eastern white pine rather than because of its greater susceptibility to the disease. The fact that none of the commercially important white pines are immune to white pine blister rust, and that most are moderately to highly susceptible, strengthens the validity of their being grouped taxonomically.

Because the white pines are such a closely related taxonomic group occurring naturally or succeeding as exotics only over a relatively narrow range of climatic conditions, consideration of their diseases can lead to but one conclusion: Any disease of any species of white pine anywhere in the world must be looked upon as a potential threat to any other species of white pine growing any place else in the world. This would appear to be especially true of any limb or stem rusts that

might follow the pattern set by white pine blister rust.

A second group of disease-causing organisms warranting particularly close attention are the dwarfmistletoes. Serious damage in native stands of *Pinus aristata*, *P. flexilis*, and *P. griffithii* is caused by these parasites. There are some indications that the dwarfmistletoes on the white pines are relatively host specific but until this is confirmed, care should be taken to prevent their introduction into new environments. Being seed-bearing plants, the dwarfmistletoes would appear far less likely to be transported unknowingly than are disease-causing fungi.

To be completely on the safe side, white pines should not be moved between continents, between countries, or even regionally within a country, except as treated seed.

The list of causal organisms that follow is by no means complete. It is representative, however, and is thought to include the potentially most serious pathogens. Hosts are designated according to the numbers given when enumerating the white pine species at the beginning of this report. It will become obvious in going through this list that many diseases are recorded in many countries on eastern and western white pines, for example, and that few are recorded in any country for Mexican white pine and Japanese white pine, as converse examples. It should be stressed once again that this is not necessarily a true expression of the relative disease susceptibility or resistance of the individual species but rather an expression of its extended range and economic importance and hence the degree of attention its pathology has so far received.

SEEDLING DISEASES

The white pines are important species in nursery production of forest trees because they are so widely used as introductions for reforestation and afforestation. Any organism capable of damaging white pine seedlings must therefore be considered potentially important where climatic and edaphic factors are favorable for its development. Good nursery practices, seed treatment, and soil fumigation can do much to minimize possible losses.

Causal organism and type of damage	Hosts and where reported
Botrytis cinerea Pers. ex Fr. Gray mold of seedlings	(6, 8) Japan
Cylindrocladium scoparium Morg. Root and stem rot of seedlings	(15) USA

Dermatea _livida_ (B. & Br.) Phillips (imp. stage _Myxosporium_ _abietinum_ Rostr.) Root collar girdle of conifers; serious.	(15) Denmark
Fusarium spp. Root rot of seedlings	(10) USA (15) Canada, USA
Macrophomina _phaseoli_ (Maubl.) Ashby (_Sclerotium_ _bataticola_ Taub.) Root rot of seedlings	(10) USA
Pellicularia _vaga_ (Berk. & Curt.) Rogers ex Linder (_Corticium_ _vagum_ Berk. & Curt.) Root and stem rot of seedlings	 (15) USA
Phytophthora _cactorum_ (Leb. & Cohn) Schroet Seedling blight, crown canker; soil borne	(15) Germany
Phytophthora _cinnamomi_ Rands Root rot of seedlings	(10, 15) USA
Pythium _debaryanum_ Hesse Root rot	(15) Bulgaria, Canada
Pythium _ultimum_ Trow. Damping off	(15) USA
Rhabdospora _mirabilissima_ (Pk.) Dearn. Stem canker of seedlings	(15) USA
Rhizina _undulata_ Fr. Seedling blight	(11) USA
Rhizoctonia _solani_ Kuehn Damping off	(15) USA
Thelephora _terrestris_ Fr. Seedling blight	(11, 15) USA

ROOT DISEASES

Root diseases are of potential importance, at least locally, once a plantation becomes infested. Since extensive controls are generally impractical, prevention through planting only locally produced disease-free stock is the safest practice.

Causal organism and type of damage	Hosts and where reported
Armillaria mellea (Fr.) Quél. Has caused heavy damage in many countries on a wide variety of species; relative pathogenicity not fully clarified; also noted as a nursery disease of sugar pine in California	(6) Denmark, Germany, Gt. Brit., Switzerland (7) Canada, Pakistan, USA (8) Germany, India, Pakistan (9) Japan (10) Australia, USA (11) Canada, Germany, USA (15) Belgium, Canada, Czechoslovakia, Denmark, Germany, Gt. Brit., Japan, New Zealand, Poland, Switzerland, USA
Coniophora puteana (Fr.) Karst. Root (and butt) rot	(15) Canada, USA
Corticium fuscostratum Burt Root (and butt) rot	(15) Canada, USA
Corticium galactinum (Fr.) Burt Root rot	(15) Canada, USA
Fomes annosus (Fr.) Karst. Root (and butt) rot; becoming more and more important as a killing root rot in plantations at time of first thinning	(1, 10, 11, 15) USA (6) Norway (8) Belgium, India, Pakistan, USA (12) Japan (15) Belgium, Canada, Czechoslovakia, Denmark, Germany, Gt. Brit., Netherlands, Switzerland
Helicobasidium mompa Tanaka Violet root rot	(9, 12, 15) Japan Known also in Korea and Taiwan on other hosts

One of the most important soil borne diseases in Japan; native Pinus parviflora and the introduced P. strobus very susceptible; purple rhizomorphs on the surface of roots and lower trunk and purplish-brown (in spring), sessile, resupinate, velvety sporophores on basal trunk serve to identify the causal organism; kills fine roots and, when severe, the cambial portion of larger roots resulting in smaller, yellowish foliage, premature leaf fall, and eventual death; no effective controls known.

Merulius sp. Root (and butt) rot	(11) USA (15) Canada
Odontia bicolor (Fr.) Bres. White root (and butt) rot	(11) Canada (15) Canada, USA
Omphalia campanella Fr. Root (and butt) rot	(15) Canada
Polyporus gilvus (Schw.) Fr. On roots (rare)	(8) Pakistan
Polyporus schweinitzii Fr. Root (and butt) rot	(1, 7, 10, 11) USA (15) Canada, Denmark, Germany, Netherlands, Sweden, USA
Polyporus tomentosus Fr. (including P. tomentosus var. circinatus (Fr.) Sartory & Maire) Red root (and butt) rot	(8) India (10, 11, 15) Canada, USA
Poria sericeomollis (Rom.) Egel. (Poria asiatica (Pilát) Overh.) Root (and butt) rot	(15) Canada
Poria subacida (Pk.) Sacc. Root (and butt) rot	(11, 15) Canada, USA
Poria weirii Murr. Yellow ring rot	(11) Canada, USA
Rhizina undulata Fr. (Rhizina inflata (Schaeff.) Quél.) Root rot of seedlings; on areas following fire	(11) USA (15) Germany, USA
Rosellinia radiciperda Mass. Root rot; serious on newly cleared land	(15) New Zealand
Rosellinia thelena (Fr.) Rab. On roots	(11) USA
Sparassis radicata Weir Yellow mottled root rot	(11) USA
Sparassis ramosa (Schaff.) ex Schroet.	(15) Germany

Thelephora terrestris Fr. Root rot	(11) USA
Verticicladiella sp. Root stain; girdling and killing	(15) USA

STEM DISEASES

The white pines are grown commercially for products utilizing the wood without modification except for shaping, i.e., pattern stock, siding, interior trim, and the like. Any stem disease that detracts from this type of use is almost as important as a killing disease. Important also among the stem defects of the white pines are the fungus blue stains but they are not included here since they do not occur in the living tree.

Cankers

As a general class, canker diseases present no critical problems to white pine production. Exceptions do occur when trees and stands are of low vigor because of poor site quality or mismanagement, especially where an attempt is made to grow a given species too far removed from its natural range or natural habitat.

Causal organism and type of damage	Hosts and where reported
Aleurodiscus amorphus (Pers.) Rab. Canker	(15) USA
Atropellis pinicola Zeller & Gooding Branch and stem canker staining wood	(1, 10, 15) USA (11) Canada, USA
Atropellis piniphila (Weir) Lohman & Cash	(1) USA (11) Canada, USA
Atropellis tingens Lohman & Cash Canker (little importance)	(11) Canada (15) Canada, USA
Aureobasidium pullulans (d By.) Arn. (Pullularia pullulans (d By.) Berkhout) Flagging disease	(11) Canada
Botryosphaeria dothidea (Fr.) Ces. & de N. (Botryosphaeria ribis Gross. & Dug.) On branches	(15) USA
Caliciopsis pinea Pk. Branch and stem canker	(11) Canada (by inoc.) (15) Canada, USA

Cenangium abietis (Pers.) Duby Dieback of pines	(6) Gt. Brit. (11) Germany, Poland, USA, (15) USA
Cenangium ferruginosum Fr. (impf. stage Brunchorstia destruens Eriks.) Canker; serious on eastern white pine in Switzerland	(6) (13) Finland (7) USA (8) Pakistan (11) Canada, USA (15) Austria, Finland, Germany, Poland, Switzerland, USA
Coccomyces strobi Reid & Cain Stem lesions on young trees	(15) Canada, USA
Crumenula pinicola (Fr.) Karst. Pine dieback, wounding branches and trunks; can kill	(15) Denmark, Germany, Norway
Crumenula sororia Karst Pine dieback	(6) USSR
Cucurbidothis pithyophila (Fr.) Petr. (Cucurbitaria pithyophila (Fr.) de N.) Bark canker	(6) Germany, (7) USA (11) Canada, USA (15) Denmark, Germany, USA
Cytospora curreyi Sacc. Conifer canker	(15) Denmark
Cytospora pini Desm. Canker	(15) Canada
Dasyscyphus acuum (Fr.) Sacc.	(15) Canada
Dasyscyphus agassizii (Berk. & Curt.) Sacc.	(7) USA (11, 15) Canada, USA
Dasyscyphus aridus (Phill.) Sacc.	(1, 7) USA
Dasyscyphus calyciformis (Willd.) Rehm Canker; wound pathogen	(11) Denmark, Gt. Brit.
Dasyscyphus ellisianus (Rehm) Sacc. Conifer bark canker	(6) USA
Dasyscyphus fusco-sanguineus Rehm (Lachnella fusco-sanguinea (Rehm) Karst.)	(1, 7) Canada, (8) Pakistan (11) Canada, USA, (15) USA

Dasyscyphus pini (Brunch.) Hahn & Ayres Twig and branch canker	(1, 11) Canada, USA (15) USA
Diaporthe eres Nits. (imp. stage *Phomopsis conorum* (Sacc.) Died. and *P. occulta* (Trav.) Canker	(15) Japan, USA
Europhium trinacriforme A. K. Parker (Perfect stage of *Leptographium* sp. associated with "pole blight" disease)	(11) Canada
Excipula strobi Fr. Parasitic on stems	(15) Denmark
Fusarium heterosporum Nees emend.Raillo Branch canker	(11) Canada
Lachnellula chrysophthalma (Pers.) Karst.	(11) Canada
Monochaetia pinicola Dearn. Twig blight and canker	(15) USA
Nectria fuckeliana Booth Branch dieback	(6) Germany (15) Denmark, USA
Phacidiella coniferarum G.G. Hahn (pycn. stage *Phacidiopycnis pseudotsugae* (M. Wils.) G. G. Hahn; syn. *Phomopsis pseudotsugae* Wils., *Phomopsis strobi* Syd.) Bark canker; girdles small saplings in USA	(15) Denmark, Germany, Gt. Brit., USA
Phoma strobiligena Desm. Stem necrosis	(6) USSR (8) Gt. Brit.
Pleurotus mitis (Fr.) Quél. Trunk canker	(15) Switzerland
Scleroderris lagerbergii Gremmen (*Crumenula pinea* (Karst.) Ferd. & Jorg., *Scleroderris abietina* (Laberg.) Gremmen; impf. stage *Brunchorstia pinea* (Karst.) Hoehn.)	(6) Denmark, Gt. Brit., Norway, Sweden (7) Norway (8) Denmark (11) Gt. Brit. (15) Denmark, Gt. Brit., Norway

Scoleconectria cucurbitula (Fr.) Booth (Nectria cucurbitula (Fr.) Fr.; Scoleconectria scolecospora (Bref.) Seaver) Weak parasite associated with branch and trunk cankers	(6) Germany (15) Canada, Denmark, Gt. Brit., USA
Trichoscyphella calycina (Fr.) Nannf. (Dasyscyphus subtilissimus (Cke.) Sacc. Pine canker	(15) Norway
Trichoscyphella resinaria (Cke. & Phill.) Conifer canker	(8) Gt. Brit.
Tympanis confusa Nyl. Weak parasite associated with branch and trunk cankers	(1, 11, 15) USA (15) Canada
Tympanis pithya (Karst.) Karst. Canker	(1) USA (15) Canada, USA
Valsa abietis Fr. On bark and twigs	(15) USA
Valsa kunzei Fr. Canker	(8, 15) USA
Valsa pini (Alb. & Schw.) Fr. Widespread on twigs and branches	(11) Canada, USA (15) Canada, Denmark, USA
Valsa superficialis Nits. Seriously damaging to this intro. in Mich.	(8) USA

Rusts

All known limb or stem rusts of the white pines are of proven or potential importance as killing diseases and as such warrant special attention to prevent their further spread and their introduction into new territories.

Causal organism and type of damage	Hosts and where reported
Cronartium ribicola Fisch. White pine blister rust; O & I on white pines; II & III on Ribes spp. Most serious disease of white pines	See Table 1 (The author welcomes notification of errors and/or omissions)

TABLE 1. Known distribution of white pines and of white pine blister rust (Cronartium ribicola Fisch.) on them.

Species of white pine and its relative susceptibility to rust 2/ — Country 1/	1 Albicaulis (ES)	2 Aristata (MS)	3 Armandi (R)	4 Ayacahuite (S)	5 Balfouriana (MS)	6 Cembra (R)	7 Flexilis (S)	8 Griffithii (R)	9 Koraiensis (R)	10 Lambertiana (ES)	11 Monticola (VS)	12 Parviflora (R)	13 Peuce (MS)	14 Strobiformis (S)	15 Strobus (S)
Australia						0	0	0		0	0				0
Austria								0							x
Belgium	0	0		x	x	x	x	x		x	x	0			x
Canada	x		0			x	x	0		x	x				x
Ceylon							0								
Chile															0
Czechoslovakia		0				x		0							x
Denmark						0	x	x			x				x
Finland						x	0				x		x		x
France	0	0	0		x	x	x	0		x	0	0	0	x	x
Germany	0	x			x	x	x	x	x	x	x	0	x		x
Great Britain	x	x	0	x	x	x	x	x	0	x	x	x	x		x
Hungary							0								0
Iceland		0				0									
India								x							
Italy						0		0	0	0		0	0		x
Japan								x							0
Kenya				0				0		0					
Korea									x						
Netherlands		0			0	0	0	0	0	0	0	0	0		x
New Zealand								0		0	0				0
Norway					0	x	x						x		x
Nyasaland														0	
Pakistan							0	x							
Poland						x				0	0				x
Portugal										0					0
Rumania															x
Southern Rhodesia						0									0
Sweden	x				0	x	x	x	x		x				x
Switzerland	0					x	0	x							x
Uganda															0
Union South Africa															0
United States	x	x	0		x	x	x	x	x	x	x	x	x	x	x
USSR						x	x			0			x		x
Yugoslavia						0	0	0	0				0		x

1/ 0 = species represented outside natural range but no rust noted.
x = white pine blister rust present.

2/ (ES) = species extremely susceptible to rust; (VS) = very susceptible; (S) = susceptible; (MS) = moderately susceptible; (R) = resistant.

White pine blister rust is already distributed essentially around the world in the Temperate Zone; further movement of white pines even internally, except as seed, should be scrupulously avoided to prevent spread into those localities not yet invaded; the known distribution and hosts of Cronartium ribicola on pines are summarized in Table 1. Ribes eradication is a proven method of control but has physical and economic limitations. Chemical control and breeding for resistance are receiving serious research attention and both offer considerable promise.

Peridermium kurilense Diet. (Cronartium kamtschaticum Jørst. (?)) Stem rust on Pinus cembra var. pumila; on Pedicularis spp. in Japan, Kamchatka, and Sakhalin; on Castilleja spp. in Siberia	(6) Japan, the Kuriles, and Kamchatka
Melampsora pinitorqua Rostr. Pine twist rust; alternates to Populus spp. Principally on hard pines but inoculations show several other coniferous genera susceptible	(8) Italy; by inoc. (15) Gt. Brit.

Heart Rots

Of the numerous heartrots recorded for white pines, none is a generally critical factor in timber production except when trees or stands are grown to great age. Lowering rotation ages and prevention of wounds on residual trees under systems of partial cutting will go far to minimize such losses.

Causal organism and type of damage	Hosts and where reported
Coniophora puteana (Fr.) Karst. (Coniophora cerebella Pers.) Butt (and root) rot	(15) Canada, USA
Corticium fuscostratum Burt Butt (and root) rot and stain	(15) Canada, USA
Corticium galactinum (Fr.) Burt Butt (and root) rot	(11) Canada (15) Canada, USA
Echinodontium tinctorium Ell. & Ev. White stringy trunk rot	(11) USA

Fomes annosus (Fr.) Karst. Butt (and root) rot	(6) Norway (11) USA (15) Canada, USA
Fomes cajanderi Karst. (Fomes subroseus (Weir) Overh.)	(11) USA (15) Canada
Fomes nigrolimitatus (Rom.) Egel. White pocket rot	(11) USA
Fomes officinalis (Fr.) Faull (F. laricis (Jacq.) Murr.) Brown cubical trunk rot	(6) USSR (10, 15) USA (11) Canada, USA
Fomes pini (Fr.) Lloyd (Trametes pini (Thore) Lloyd) Red ring rot; a white pocket rot reported as serious in Pakistan	(1, 7, 10) USA (3) Taiwan (6, 10) USSR (8) India, Pakistan (9) USSR (11) Canada, Gt. Brit., USA (13) Yugoslavia (14) Yugoslavia, USA (15) Canada, Denmark, Germany, Poland, USA
Fomes pinicola (Fr.) Cke. Brown crumbly heart rot	(1, 2, 7, 10, 14, 15) USA (8) Pakistan (11) Canada, USA (15) Canada
Fomes roseus (Fr.) Karst. Brown cubical heart (top) rot	(10, 11, 14, 15) USA (15) Canada
Ganoderma tsugae Murr. (Polyporus tsugae (Murr.) Overh.)	(15) Canada
Lentinus lepideus Fr. Saprot, but sometimes a heart rot	(1, 11, 15) USA
Merulius himantioides Fr.	(15) Canada, USA
Merulius sp. Butt (and root) rot	(11) USA (15) Canada
Odontia bicolor (Fr.) Bres. Butt (and root) rot	(11) Canada (15) Canada, USA
Omphalia campanella Fr. White stringy butt (and root) rot	(15) Canada

Polyporus anceps Pk. Red ray rot; a white pocket heart rot	(11, 15) USA
Polyporus balsameus Pk. Brown cubical butt rot	(11) USA (15) Canada
Polyporus cinnabarinus Fr. White rot	(15) Canada
Polyporus leucospongia Cke. & Harkn. Brown cubical rot	(1, 15) Canada (7) USA
Polyporus schweinitzii Fr. Red brown butt (and root) rot	(1, 2, 5, 7, 14) USA (8) Pakistan (11) Canada, USA (12) Japan (15) Canada, Denmark, Germany, Sweden, USA
Polyporus sulphureus Fr. Brown cubical heart rot	(11, 15) Canada, USA
Polyporus tomentosus Fr. (Including P. tomentosus var. circinatus (Fr.) Sartory and Maire) White pocket butt (and root) rot	(8) India (11, 15) Canada, USA
Poria albobrunnea (Rom.) Baxter Brown rot	(11) USA
Poria cocos (Schw.) Wolf Brown cubical butt rot	(10) USA (11) Canada, USA
Poria monticola Murr. Brown cubical rot	(11) Canada, USA
Poria sericeomollis (Rom.) Egel. (Poria asiatica (Pilát) Overh.) Brown cubical butt (and root) rot	(15) Canada
Poria subacida (Pk.) Sacc. White spongy butt (and root) rot	(11, 15) Canada, USA
Poria vaporaria (Fr.) Cke. (Poria sinuosa (Fr.) Cke. Brown heart rot	(10, 11, 15) USA

Sparassis crispa (Wulf.) Fr. (Sparassis ramosa (Schaeff.) Schroet.) Heart rot; wound parasite	(15) Germany
Stereum chailletii (Fr.) Fr.	(11, 15) Canada
Stereum purpureum (Fr.) Fr. White spongy rot; wound parasite	(8) Pakistan
Stereum sanguinolentum (Fr.) Fr. Brown cubical heart rot; may enter through pruning wounds	(6) Norway (11, 15) Canada, USA

Mistletoes and dwarfmistletoes

Silvicultural control of the dwarfmistletoes can be achieved through careful thinning and pruning; one or more follow-up operations being required to clean up latent infections or infections missed the first time over. Fortunately, once a stand is thoroughly cleaned, the benefits last for the remainder of the rotation or even longer. Research on their chemical control already shows promise where the plant parasite or the site of infection can be treated directly.

Causal organism and type of damage	Hosts and where reported
Arceuthobium americanum Engelm. Lodgepole pine dwarfmistletoe; typically on lodgepole and jack pines; a cross-over to the species listed where growing in immediate association with type host	(1, 2, 7) USA
Arceuthobium campylopodum Engelm. f. blumeri (A. Nelson) Gill Western dwarfmistletoe; typically confined to the hosts listed	(10, 14) Mexico, USA
Arceuthobium campylopodum Engelm. f. cyanocarpum (A. Nelson) Gill Western dwarfmistletoe; typically on bristlecone and limber pines.	(2, 7, 11) USA
Arceuthobium campylopodum Engelm. f. laricis (Piper) Gill. Larch dwarfmistletoe, typically on western larch but occasionally on western white pine in infected larch stands.	(11) Canada, USA

Arceuthobium campylopodum Engelm. f. tsugensis (Rosendahl) Gill. Hemlock dwarfmistletoe, typically on hemlock but sometimes damaging to the hosts listed.	(1, 11) Canada, USA
Arceuthobium minutissimum Hook Pole stands at 10,000-11,000 feet elevation badly decimated; worst in semi-arid tracts; aerial parts very minute; seed apparently bird-disseminated; causes witches'-brooms	(8) India, W. Pakistan
Arceuthobium pusillum Pk. Eastern dwarfmistletoe; attacking mainly spruces, reported only once on white pine where a cross-over from growing in close association with spruce	(15) USA
Viscum album L. European mistletoe; very dangerous to hardwoods and conifers alike	(15) Germany

FOLIAGE DISEASES

Though they may be widespread and common in occurrence, foliage diseases are not generally the cause of great economic damage to white pines unless unusually severe and sustained at an epiphytotic level for several years in succession. Control of foliage diseases has not yet been found practical in commercial forestry operations except in the forest nursery. As with most any disease, however, maintaining good tree and stand vigor is helpful.

Causal organism and type of damage	Hosts and where reported
Bifusella linearis (Pk.) Hoehn. Tar spot needle cast, kills old needles	(5, 7) USA (11, 15) Canada, USA
Cercospora pini-densiflòrae Hori & Nambu Needle blight; eastern white pine very susceptible where planted in Japan	(15) Japan, Taiwan
Coleosporium barclayense Bagchee (Peridermium brevius (Barc.) Sacc., aecial stage) Alternates from needles to Senecio spp.	(8) India, Pakistan

Coleosporium crowellii Cumm. Needle rust, autoecious	(7) USA
Coleosporium pinicola (Arth.) Arth. Needle rust, autoecious	(6) USSR
Coleosporium spp. Needle rusts; alternating to a variety of herbaceous species; seldom damaging.	(3, 6, 8, 9, 11, 15) variously in Asiatic countries
Crumenula pinicola (Fr.) Karst.	(15) Denmark, Norway
Diplodia pinea (Desm.) Kickx (Sphaeropsis ellisii Sacc.) Leaf and twig blight, dieback	(15) Gt. Brit., USA
Hendersonia foliicola (Berk.) Fckl. Browned needles	(15) USA
Hypoderma brachysporum (Rostr.) Tub.	(15) Germany
Hypoderma desmazierii Duby Conifer needle cast	(6) Gt. Brit., Poland (7) Yugoslavia (8) France, Germany, Gt. Brit., USA (11) Gt. Brit. (12) Gt. Brit., USSR (13) Denmark, Yugoslavia (15) Austria, Bavaria. Canada, Czechoslovakia, Denmark, France, Germany, Gt. Brit., USA, USSR
Hypoderma pini (Dearn.) Darker	(7) USA
Hypoderma saccatum Darker	(7) USA
Hypodermella arcuata Darker Needle cast	(7, 10, 11) USA
Hypodermella montivaga (Petr.) Dearn.	(7, 11) USA
Lecanosticta sp. Needle blight	(11) USA
Leptostroma ahmadi Petr. On needles	(8) Pakistan

Leptothyrium stenosporum Dearn. Needle blight	(15) USA
Lophodermium nitens Darker Needle cast	(1) Germany, USA (6) Austria, France (7) Canada, USA (8, 10) USA (11) Canada, USA (15) Canada, Germany, USA
Lophodermium pinastri (Fr.) Chev. Needle cast	(1, 3, 5, 9, 12) USA (3) Norway (6) Denmark, Finland, Germany, Norway, Sweden, Switzerland, USSR (7) Norway, USA (8) India (9) USA, Yugoslavia (10) Canada (11) Denmark, Finland (15) Belgium, Canada, Denmark, Finland, Germany, Japan, Norway, USA
Lophodermium pini-excelsa Ahmad Needle cast	(8) Pakistan
Melampsora oblonga Bagchee Needle rust; autoecious	(8) India
Neopeckia coulteri (Pk.) Sacc. Brown felt blight	(1, 7) Canada, USA (5, 11, 15) USA (6) Switzerland
Phacidium infestans Karst. Conifer snow blight	(6) Austria, Sweden, Switzerland (15) Canada, Sweden, USA
Phacidium pini-cembrae (Rehm) Terrier Needle blight; kills lower portions of young trees and lower branches of old trees	(6) Italy
Phacidium planum J. J. Davis Needle blight	(7) USA

Phoma strobiligena Desm. Cone necrosis	(6) USSR (8) Gt. Brit.
Pucciniastrum aceris Syd. Needle rust; alternates to Acer caesium Wall.	(8) India
Pucciniastrum agrimoniae (Schw.) Tranz. Needle rust; alternates to Agrimonia eupatorium L.	(8) India
Rhizosphaera pini (Cda.) Maubl. On needles	(10) USA
Scirrhia acicola (Dern.) Siggers Needle blight	(11, 15) USA
Scleroderris lagerbergii Gremmen (Crumenula pinea (Karst). Ferd. & Jorg., Scleroderris abietina (Lagerb.) Gremmen; impf. stage Brunchorstia pinea (Karst.) Hoehn.)	(6) Denmark, Gt. Brit., Norway (8) Denmark (15) Gt. Brit.
Stagonospora pini Grove Needle blight	(2) Czechoslovakia
Therrya pini (Alb. & Schw.) Hoehn.	(15) France

SYSTEMIC DISEASES

There are no virus diseases, vascular wilts or diebacks of white pines reported as being infectious. The pole blight disease of western white pine in western United States and Canada may, however, have created some concern abroad. Research to date, strongly indicates that this disease was incited by a prolonged and severe drought, affecting trees growing on soils of low moisture holding capacity and low moisture recharge potential. Pole blight does not, therefore, appear to constitute any international disease threat. Similarly, three North American diseases of eastern white pine -- chlorotic dwarf, emergency tip burn, and pre-emergency tip burn -- all appear to be related to atmospheric pollutants and hence they, too, pose no intercontinental threat.

DISEASES OF PSEUDOTSUGA[1]

by

Thomas W. Childs[2]

Importance of the Genus

There are five or more species in the genus Pseudotsuga, depending upon the number of varieties one may choose to recognize or ignore. Of the five most commonly recognized, two are native to western North America and three to the Orient in Taiwan, Japan and western China. These species and their varieties are as follows:

Pseudotsuga menziesii (Mirb.) Franco (*P. taxifolia* (Poir.) Britt.)	Douglas-fir
var. *menziesii* the typical or green form	Coast Douglas-fir
var. *glauca* (Beissn.) Franco sometimes referred to as the blue form	Rocky Mountain Douglas-fir
var. *caesia* (Schwerin) Franco recognized by some as an intermediate between *menziesii* and *glauca*, confined to the Northern Rocky mountains.	
Pseudotsuga macrocarpa (Vasey) Mayer Mountains of southern California, USA	Big-cone Douglas-fir
Pseudotsuga japonica (Shiras.) Beiss Found only in Japan	Japanese Douglas-fir
Pseudotsuga sinensis Dode A large tree in western China	Chinese Douglas-fir

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1 For distribution at FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Pacific Northwest Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Portland, Oregon

Pseudotsuga wilsoniana Hayata — Formosan Douglas-fir
At higher elevations in southwestern China and Taiwan (Formosa)

From the forestry standpoint, only one of these species, Pseudotsuga menziesii, is commercially important. In western North America, it ranges from Mexico to Canada, between latitudes 19° to 55° north, but reaches its optimum development from 40° to 55° north in the coastal areas of Oregon, Washington, and British Columbia. Great volumes of its principal varieties occur in pure or mixed stands on millions of acres under marine, montane, and continental climates. It has been planted extensively for many years in western Europe, and is being used increasingly for both reforestation and afforestation in eastern Europe and elsewhere.

On sites of fair or better quality Douglas-fir maintains a good growth rate for many decades. Although several other conifers produce more volume in small stems on short rotations, few produce as much volume in large stems on rotations of moderate length. Its behavior within its natural range suggests that it may be less likely than most species to cause site deterioration or to be subject to various other troubles often associated with pure plantings. Natural regeneration occurs abundantly under favorable conditions, and artificial regeneration offers no unusual difficulty.

Wood of Douglas-fir, especially of var. menziesii possesses workability, strength, and most other desirable and useful properties to at least a moderate degree. It is put to such diverse uses as beams and laminated trusses for heavy construction, poles and piling, railroad crossties, wooden housing, general purpose lumber, cheap furniture, plywood, and paper. Its availability in great size and length adds materially to its specialized utility.

While not outstanding in any single trait, Douglas-fir is almost unique in its combination of desirable characteristics--sustained productiveness, amenability to pure-culture management, versatility of its wood. Its present economic position is due in part to the great volumes of high-quality, large-size timber yielded by virgin stands, but even after these are exhausted it will continue to be one of the most valuable forestry species not only within its natural range but also in other climatically suitable regions.

Present and Potential Disease Impact

Native pathogens. Of the numerous pathogens indigenous on Douglas-fir, relatively few cause appreciable damage. However, there is real danger that one or more--even of those that are of little or

no consequence at present--may become seriously damaging, as Rhabdocline and Phaeocryptopus have proved to be, if they are allowed to become established in exotic stands. In evaluating the pathogens potentially damaging to Douglas-fir, consideration must be given to (1) variability within the host, and (2) variability within the pathogens.

(1) Each of the three principal varieties of Douglas-fir includes numerous local races and innumerable genotypes. These sub-varietal taxons are often indistinguishable morphologically, but they differ considerably in disease susceptibility and other physiological characters. Because of this intraspecific differentiation, it will usually be possible to find local races that are at least moderately resistant to any given indigenous disease.

On the other hand, since much of the differentiation of Douglas-fir consists of adaptations to rather slight differences in local environments, nonlocal stock is often abnormally susceptible to native pathogens, even under conditions not greatly different from those of the locality of provenience. The risk of such damage in exotic stands can be reduced by propagating from earlier introductions that have proved successful, by careful selection of seed sources, by intermingling stock of several different proveniences, and of course by effective quarantines. Nevertheless, indigenous diseases will probably be damaging to many exotic stands of Douglas-fir until stock well adapted to the locality has been obtained by breeding or through natural selection.

(1) Many of the pathogens are also variable. For example, within most species in the family Polyporaceae the existence of genotypes differing in numerous respects is easily demonstrable. Racial or varietal differentiation of pathogen species is usually less evident, but several instances are known. Intraspecific variability of agricultural pathogens is often of great pathological importance, especially in connection with plant breeding for disease resistance, and there is no reason to believe that the situation in forestry is essentially different.

Consequently, movement of a pathogen from one part of the world to another must be considered hazardous even if the pathogen belongs to a species already established in the region into which it is moved. For example, Armillaria is indigenous to every continent, and natural selection has given its hosts some degree of resistance to local races of the fungus, but we have no assurance that this resistance would be effective against introduced races. Rhabdocline was introduced into Europe many years ago, but there is more than one variety of this fungus. It is entirely possible that one or more of its varieties, perhaps still confined to North America, would cause even greater damage if introduced into Europe.

Introduced pathogens. By far the most dangerous potential threat to Douglas-fir consists of pathogens not indigenous to North America, and especially of pathogens that attack other species of *Pseudotsuga*. The most catastrophic diseases of forest trees have been caused by pathogens that originally posed only minor problems to closely related host species in distant parts of the world. The three Asiatic species of *Pseudotsuga* may or may not harbor pathogens capable of devastating Douglas-fir forests, but the only safe procedure is to take extreme precautions against spread of their diseases into other regions.

SEEDLING DISEASES

All of the seedling diseases of Douglas-fir also occur on other conifers. Damping-off, the most widespread and damaging of these diseases, is caused by several different fungi. Control of damping-off in nurseries has been obtained by such diverse methods as soil acidification, regulation of soil temperature and moisture, fall sowing, and addition of soil amendments. Methods effective in one nursery, however, may be ineffective where other pathogens are involved, and under differing soil conditions and local climates. Foliage diseases of seedlings are usually controlled in the nursery by fungicidal sprays, and in young plantations by use of stock well adapted to the locality.

Distributions in the following lists are those of pathogens and not just of their occurrence on Douglas-fir.

Causal organism and type of damage	Reported from:
Ascochyta piniperda Lindau Leaf spot, damping-off	Europe, North America
Botrytis cinerea Fr. Gray mold	Widespread
Cladosporium herbarum (Lk.) Fr. Black mold	Widespread
Fusarium spp. Damping-off, seedling root rot	Widespread
Fusoma parasiticum Tub. Damping-off	Europe, North America
Moniliopsis klebahni Burchard Damping-off	Europe

Pestalotia hartigii Tub. Stem girdle	Europe, North America
Phacidium infestans Karst. Snow blight	Europe, North America
Pythium spp. Damping-off	Widespread
Rhizoctonia spp. Damping-off	Widespread

ROOT DISEASES

Most root pathogens should not be difficult to exclude from regions where they are not already present. Several of them, however, are of almost worldwide distribution and may become seriously damaging in some exotic stands of Douglas-fir. Since they differ considerably in their environmental requirements and methods of spread and intensification, control measures also must differ considerably, according to the pathogen involved.

Root diseases are usually most damaging to intensively managed stands, and especially to first-generation conifers on hardwood sites or previously nonforested land. A few can be controlled to some extent by special measures--for example, stump treatment, or thinning only during a "safe" season. In general, root disease damage on afforested areas will probably decrease as forest soils slowly evolve there. This process may perhaps be hastened by generous inoculation of the soil with duff and topsoil from long-established coniferous forests in the vicinity.

The following list consists principally of pathogens that attack large lignified roots. Very little is now known about the nematodes, fungi, and bacteria that attack fine roots of conifers, but there is good reason to believe that this list, if complete, would include many such organisms.

Causal organism and type of damage	Reported from:
Armillaria mellea (Fr.) Quél. Shoestring root rot	Widespread
Clitocybe tabescens (Fr.) Bres. Clitocybe root rot Not reported on Douglas-fir, but reported on other Pinaceae. Very similar to Armillaria except for absence of rhizomorphs. Might be damaging in mild climates.	Europe, India, Madagascar, North America

Fomes annosus (Fr.) Cke. — Australia, North Temperate Zone
Annosus root rot

?*Leptographium* sp. — North America
Rare, but a killer. Causes dark streaks in root and butt sapwood. Difficult to obtain in pure culture.

Phymatotrichum omnivorum (Shear) Dug. — South-central U.S.A.
Texas root rot
Apparently very demanding in environmental requirements, but might be damaging in some localities on other continents.

Phytophthora cinnamomi Rands — Tropical and mild temperate
Phytophthora root rot
May be unable to persist in most forest soils. Causes severe damage to pines on some deteriorated sites in southeastern United States, and might be destructive, under some conditions, to Douglas-fir in afforestation projects.

Polyporus osseus Kalchbr. — Europe, North America
Brown crumbly root rot. Rare on this host.

Polyporus schweinitzii Fr. — Australia, North Temperate Zone
Red-brown butt rot
Sometimes causes typical root rot in young natural stands of Douglas-fir. Has seriously damaged some afforestation plantings.

Polyporus tomentosus Fr. (incl. var. *circinatus*) — Europe, India, Japan, North America
Stand-opening disease
Might be damaging on colder-than-average sites.

Poria subacida (Pk.) Sacc. — Japan, North America
Spongy root rot
A fairly common root rot of suppressed Douglas-fir, but rarely if ever of more vigorous trees, in natural stands.

Poria weirii Murr. — Japan, North America
Laminated root rot
The most damaging pathogen in young natural stands of var. *menziesii*. Also dangerous to other conifers.

Sparassis spp. — Europe, North America, Philippine Islands
Sparassis root rot

Stereum sanguinolentum Fr. Mottled bark disease Also causes damaging heart rot of young trees, entering through pruning wounds, winter-killed tops, etc.	Widespread

STEM DISEASES

Cankers

No caulicolous rusts have been reported on Douglas-fir. Most if not all of the canker-causing organisms native to this host are weak parasites, attacking only trees predisposed by drought, frost, or other environmental stress. They are usually rare in natural stands except on drier-than-average sites, and even there they seldom cause much damage.

It is impossible, of course, to predict with certainty what would happen if a North American pathogen such as the gall bacterium were to invade exotic stands, or if Douglas-fir were exposed to the diseases of its Asiatic congeners. It appears probable; however, that damage by indigenous cankering diseases can be largely prevented by using stock well adapted to the local climate, and by avoiding frost pockets and patches of droughty soils.

Causal organism and type of damage	Reported from:
Aleurodiscus spp.	Europe, North America
Bacterium pseudotsugae Hans. & R. E. Smith	North America
Brunchorstia (Scleroderris) spp.	Europe, North America
Caliciopsis pseudotsugae Fitzp.	Europe, North America
Chondropodium speudotsugae W.L. White (imp. of Durandiella pseudotsugae Funk)	North America
Cytospora (Valsa) spp.	Durope, North America
Dasyscyphus spp.	Europe, North America
Phomo douglasii Oud.	North America
Phomopsis spp.	Europe, North America
Physalospora (Guignardia) laricina Sawada Shoot blight	Japan

Unidentified — North America

Causes large, resinous cankers on pole- to sawtimber-size trees. Fairly common on good sites in a few localities in western Oregon and Washington. Potentialities unknown, but appears able to attack vigorous trees at least occasionally.

Heart rots

Most of the fungi that attack Douglas-fir heartwood are widely distributed in coniferous forests throughout the world. Since heart rot is seldom affected by physiological reactions on the part of the host, damage would probably not be increased appreciably by introduction of nonlocal races of fungus species already present.

Damage by heart rots (as distinct from root rots that spread upward into butt logs) can usually be kept low by protecting the young trees from mechanical injury and by logging before the end of the pathological rotation.

The following list includes only fungi that are not known to be widely distributed and that seem most likely to be damaging if introduced into new localities.

Causal organism and type of damage	Reported from:
Echinodontium tinctorium Ell. & Ev. Indian paint fungus	Japan, North America
Fomes subroseus (Weir) Overh. (*F. cajanderi* Karst.) Top rot Usually infects through top breaks. The most common cause of heart rot in young natural stands.	North America
Polyporus anceps Pk. Red ray rot	North America
Poria carbonica Overh. Fairly common in a few localities; associated with trunk wounds.	North America
Poria subacida (Pk.) Sacc.	Japan, North America

Mistletoes

Parasitic seed plants do not appear to constitute a serious hazard to exotic stands. One species of *Arceuthobium* is common and

damaging in parts of the natural range of Douglas-fir, and other species of this genus (and one species of Phoradendron) have been reported on this host. It should not be difficult, however, to exclude such parasites from regions to which they are not indigenous, or to control them by local sanitation in intensively managed stands.

Causal organism and type of damage	Reported from:
Arceuthobium douglasii Engelm. Douglas-fir dwarfmistletoe	North America

FOLIAGE DISEASES

Possibility of increased damage by foliage pathogens must not be ignored. The impact of Rhabdocline (only moderately damaging in North America) and Phaeocryptopus (unimportant in North America) on European forests should serve as an emphatic warning against the introduction of any pathogen.

Little control is possible at present, except that Rhabdocline damage can be reduced considerably by using host var. menziesii (most of whose races are relatively resistant) where winters are mild enough to be tolerated by this variety. Control by systemic antibiotics may become practicable within a few years.

Causal organism and type of damage	Reported from:
Herpotrichia nigra Hartig Brown felt blight Common only in localities with heavy snowfall.	North Temperate Zone
Leptothyrium pseudotsugae Dearn. Flyspeck	North America
Melampsora albertensis Arth. Needle rust Fairly common but causes little or no damage on vars. caesia and glauca; occasional on var. menziesii. Uredia and telia on Populus spp. Might be highly damaging if introduced into Europe.	North and South America
Phaeocryptopus gaümanni (Rohde) Petr. Needle cast Locally common in North America but mostly on old needles or those moribund from other causes. Damaging in Europe.	Europe, North America
Rhabdocline pseudotsugae Syd. (?Imp. = Rhabdogloeum spp.) Needle cast.	Europe, North America

There are at least three recognizable varieties of the perfect stage of this fungus. Most but not all local races of host var. menziesii are relatively resistant.

SYSTEMIC DISEASES

No viral or systemic dieback diseases of this host are known. Several "sapstain" fungi, mostly species of *Ceratocystis*, occur in living trees but only in the immediate vicinity of wounds or in association with bark-beetle attacks. While these fungi almost certainly hasten death of infested trees, they cannot be considered primary causes of disease.

DISEASES OF SEQUOIA[1]

by

Robert V. Bega[2]

Importance of the Genus

The two living sequoias, Sequoia sempervirens (D. Don) Endl. and S. gigantea (Lindl.) Decne., are the only remaining species of many that flourished over much of the Northern Hemisphere in tertiary times. The natural ranges of both species are now restricted almost entirely to California, although limited commercial and ornamental plantings can be found throughout the world. There are no known hybrids in either species, but each has 3-5 varieties or cultivars. These are used only as garden varieties. Both species, however, have a place in forestry because of their economic importance as timber trees, and because of their great age and large size. S. gigantea is the most massive of all trees in the world in terms of volume, with many individuals having a gross volume of more than 500,000 board feet.

The first known and the more economically valuable species is S. sempervirens (redwood, coast redwood or California redwood). It is considered by many authorities to be one of the more valuable timber species in the world even though it is comparatively limited in distribution. In its natural range it is restricted to a belt of humid coastal territory about 450 miles long and 20 miles wide from the southwest corner of Oregon to Monterey County in California. Statistics in 1963 set 1.6 million acres as the amount of productive redwood forest land in California with an annual cut of 1.2 billion board feet. It is considered one of the five major forest types in California with the primary cut being saw logs (97.5 percent) and the remainder split products. The wood, although relatively weak, is durable and very resistant to weathering and decay. It is especially valuable for use in general building, boxes, furniture, panelling, shingles, fence posts, and trellis supports for grapevines.

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, California

The most famous of the sequoias and the most widely known of all living conifers is S. gigantea, commonly called giant sequoia, Sierra redwood, or big tree. It is one of the rarest of all living tree species and interest attached to it is distinctly international. In the United States because of common usage the accepted name is Sequoia gigantea even though the proper designation under the International Code of Botanical Nomenclature is S. wellingtonia. Buchholz' segregation of the species from Sequoia as Sequoiadendron giganteum is used only by a limited number of authors. Within its natural range it grows in several isolated groves on the western slope of the Sierra Nevada in central California and requires a much colder, drier habitat than does the coast redwood. Most groves are in public land withdrawn from cutting with only 12 percent of the total acreage in private ownership; as a consequence, very few trees are being cut. In 1952, about 2 million board feet were harvested. The wood is brittle, more so than that of coast redwood, and is difficult to work. Like that of coast redwood the timber is very resistant to weathering and decay. Fallen logs in the forest have remained sound for centuries. The wood is used primarily for posts, shingles, and vine stakes, but is no longer in general use because of the restrictions on cutting.

Present and Potential Disease Impact

Based partly on the role they have assumed in science, history, and popular literature, legend has it that the sequoias are disease-free species. Except for heart rots of S. sempervirens the pathology of the two species is not well known, but as survey and research efforts are increased in California, and as reports from other countries continue to accumulate, it becomes obvious that the species are not as "disease free" as once assumed. Few important natural enemies of giant sequoia have been found to date, but when moved out of its natural range it is highly susceptible and rapidly killed by several organisms that may attack it at any stage from seedlings to mature trees. The coast redwood, although having more natural enemies than the giant sequoia, also is damaged less in its natural range than when moved to new areas.

In several areas of the United States and in other parts of the world, notably Japan, diseases can be a prime limiting factor in commercial production of either species. The list of organisms presented in this report shows that both species of sequoia are susceptible, in all stages of growth, to several pathogens. The majority of the organisms listed below were taken from unpublished records gathered in California over the past several years. These listings were taken from the herbaria of the Pacific Southwest Forest and Range Experiment Station, Berkeley, and the Department of Botany, University of California, Berkeley. Because many of the causal organisms are of worldwide distribution, this listing should

serve to indicate the potential importance of these organisms when sequoias are planted outside their natural range. The symbols used in the list are as follows: I, *Sequoia gigantea*; II, *S. sempervirens*. The majority of the diseases listed as U.S.A. are reported from California.

SEEDLING DISEASES

Except for very recent work on *S. sempervirens*, few investigations have been made of diseases of seedlings in their natural habitat. Experience in California nurseries, however, has shown that both hosts are susceptible to the common nursery pathogens causing pre- and post-emergence damping-off and later stage root diseases. Seed treatment and soil fumigation have done much to minimize nursery losses from soil-borne organisms in California.

Causal organism and type of damage	Hosts and where reported:
Agrobacterium tumefaciens (Smith et Townsend) Conn. Crown gall	I and II U.S.A.
Botrytis cinerea Pers. ex Fr. Seedling blight, also may cause losses in storage	I and II U.S.A., Great Britain, New Zealand
Botrytis douglasii Tub. (? *B. cinerea*) Seedling blight	I and II U.S.A.
Cercospora cryptomeriae Shirai (Similar to *C. sequoiae* in U.S.A.) Needle and shoot blight. Considered to be the main reason why *S. gigantea* does not grow well in Japan.	I Japan
Cercospora exosporioides Bubak. Needle blight. Causes severe losses in seedling stage	II Japan
Fusarium oxysporum Schlecht. amend Snyd. & Hans. Several clones of this species are associated with damping-off and root rots of seedlings in nurseries. Pathogenicity has not been established.	I and II U.S.A.

Macrophomina phaseoli (Maubl.) Ashby (Sclerotium bataticola Taub.) Charcoal root disease. Causes severe losses in damping-off stage and later as a root disease of 1- and 2-year-old seedlings in California nurseries	I U.S.A.
Phomopsis pseudotsugae Wils. Stem canker	I Great Britain
Phytophthora cinnamomi Rands Root rot. Losses in California resulted when S. gigantea was planted in old avocado orchards	I U.S.A.
Phytophthora spp. Damping-off in California nurseries	I and II U.S.A.
Pythium ultimum Trow. Damping-off in California nurseries	I U.S.A.
Pythium spp. Damping-off in nurseries. Also reported to be a major cause of loss of natural seedlings of S. sempervirens.	I and II U.S.A.
Rhizoctonia solani Kuhn Damping-off, also root disease of older seedlings in California nurseries. Along with Pythium spp. reported to be a major cause of loss of natural seedlings of S. sempervirens.	I and II U.S.A.

ROOT DISEASES

Root diseases, other than those encountered in the nursery, have caused heavy losses in several plantations in California. Except for occasional observations few investigations have been made of root diseases in natural stands.

Causal organism and type of damage	Hosts and where reported:
Agrobacterium tumefaciens (Smith et Townsend) Conn.	II U.S.A.

Crown gall. Found on several young plants in California, but believed traceable to a single nursery.

Armillaria mellea (Vahl) Quél. Shoestring root rot. Can be very damaging in plantations in California when either species is planted outside its natural range.	I and II U.S.A.
Fomes annosus (Fr.) Cke. Annosus root rot. Causes limited decay of wood.	I and II U.S.A.
Phymatotrichum omnivorum (Shear) Dug. Texas root rot	II U.S.A.
Phytophthora cinnamomi Rands Root rot. Caused losses in Christmas tree plantations on old avocado land in California.	I U.S.A.
Rhizoctonia solani Kuhn Root rot in young plantations in California.	I U.S.A.

STEM AND FOLIAGE DISEASES

With the possible exception of _Coryneum_ sp. on _S. sempervirens_, stem and foliage diseases are of minor or at least of sporadic importance in natural stands. In plantations and ornamental plantings outside the natural range of both species, however, these diseases can be a limiting factor in survival.

No attempt has been made in this listing to achieve taxonomic perfection. It is left to the reader's discretion to determine what he considers synonomy among genera and species. The question marks (?) preceding the type of damage indicate that the causal association of the pathogen has not been proved.

Causal organism and type of damage	Hosts and where reported:
Acanthostigma sequoiae (Plowr.) Sacc. Needle blight	I U.S.A.

Amphisphaeria _wellingtoniae_ (Cke. & Hk.) Berl. & Vogl. ? Needle blight	II U.S.A.
Botryosphaeria _ribis_ Gross. & Dug. Branch and stem canker. Causes severe damage in California on _S. gigantea_ when planted out of its natural range. Progressive damage on a given tree can be so severe as to cause mortality. Trees as large as 5 feet in diameter have been killed by the fungus.	I U.S.A.
Botrytis _cinerea_ Pers. ex. Fr. Twig blight. Frequently follows frost damage.	II U.S.A.
Cercospora _cryptomeriae_ Shirai Needle and shoot blight	I Japan
Cercospora _exosporioides_ Bubak. Needle blight	II Japan
Cercospora _sequoiae_ Ell. & Ev. Needle blight. (May be the same as _C. cryptomeriae_ in Japan)	I U.S.A.
Chloroscypha _chloromela_ (Phill. & Harkn.) Seaver ? Needle blight	II U.S.A.
Clithris _sequoiae_ Bonar On twigs	II U.S.A.
Coryneum sp. Canker on stump shoots and plantation trees in the natural range of _S. sempervirens_. It has also been found in the tops of old-growth redwood. The threat posed by the disease in California is currently being evaluated.	II U.S.A.
Cytospora _pinastri_ Fr. Twig blight	II U.S.A.

Dermatea _livida_ (Berk. & Br.) Phill. Stem canker	II U.S.A.
Leptothyrium _pseudotsugae_ Dearn. ? Twig blight	I U.S.A.
Macrophoma sp. Twig blight	II U.S.A.
Mycosphaerella _sequoiae_ Bonar Needle blight. Damage can be severe in natural stands during climatically favorable years but has never reached epiphytotic proportions.	II U.S.A.
Microdiplodia _cupressina_ (Cke.) Tassi. Twig blight	I U.S.A.
Pestalotia _funerea_ Desm. Needle blight	I U.S.A.
Pestalotia sp. ? Twig blight	I U.S.A.
Phomopsis _juniperovora_ Hahn ? Twig blight	I U.S.A.
Phomopsis _occulta_ Trav. ? Twig blight	I and II U.S.A.
Phomopsis _pseudotsugae_ Wils. Stem canker	I Great Britain
Wallrothiella _consociata_ (Ell. & Harkn.) Ell. & Ev. ? Needle blight	I U.S.A.

HEART ROTS

An unidentified heart rot fungus causes some decay in large _S. gigantea_ where heartwood has been exposed. Although sapwood rots rapidly, old trees that fell centuries ago show little evidence of decay in the heartwood.

Only two species of fungi are able extensively to destroy heartwood in S. sempervirens. Yet because of these two organisms over 20 percent of the gross volume in old-growth redwood stands is culled. Cull resulting from Poria sequoiae and P. albipellucida represents 10 billion board feet or 92 percent of the total cull in standing redwood. These rots also contribute to additional loss through excessive breakage when defective trees are felled.

With exception of the two above mentioned fungi, those decay fungi listed below cause only limited decay in the vicinity of wounds or other injuries that expose heartwood. Some have been found only in logs on the ground.

Causal organism and type of damage	Hosts and where reported:
Fomes annosus (Fr.) Cke. Butt rot	II U.S.A.
Ganoderma sequoiae Murr. Wood rot	II U.S.A.
Hexagonia carbonaria Berk. & Curt. Wood rot	II U.S.A.
Hymenochaeta tabacina (Sow. ex Fr.) Lév. Wood rot	II U.S.A.
Lenzites saepiaria Wulf. ex Fr. Wood rot	I U.S.A.
Merulius hexagonoides Burt. Wood rot	II U.S.A.
Polyporus abietinus (Dicks.) Fr. Limited sapwood decay	II U.S.A.
Polyporus amorphus Fr. Wood rot	II U.S.A.
Polyporus sulphureus Bull. ex Fr. Wood rot	II U.S.A.
Polyporus versicolor L. ex Fr. Wood rot	II U.S.A.
Poria albipellucida Baxter White ring rot. Prevalent in the northern part of the redwood belt. Responsible for 28 percent of the decay in old-growth redwood.	II U.S.A.

Poria incrassata (Berk. & Curt.) Burt. Dry rot of timber; also found growing in the bark of living trees	II U.S.A.
Poria sequoiae Bonar Brown, cubical rot. Responsible for nearly 72 percent of total decay in old-growth redwood. May be the fungus responsible for decay in _S. gigantea_.	II U.S.A.
Poria versipora (Pers.) Rom. White rot of sapwood	II U.S.A.
Schizophyllum commune Fr. Wood rot	II U.S.A.
Stereum fasciatum Schw. Wood rot	II U.S.A.
Stereum hirsutum Willd. ex Fr. Wood rot	II U.S.A.
Trametes americana Overh. Wood rot	II U.S.A.
Trametes carbonaria (Berk.& Curt.) Overh. Wood rot	II U.S.A.
Trametes tenuis Karst. Wood rot	II U.S.A.

GALLS

Branch galls (other than crown gall) have been reported on _S. sempervirens_ from several areas of Europe and the United States. These galls are nearly always associated with individual trees and have shown no sign of spread except within a given tree. In some instances bacteria have been isolated from the galls but have never been satisfactorily proved to be pathogenic.

DISEASES OF THUJA[1]

by

Orson K. Miller, Jr.[2]

Importance of the Genus

The genus *Thuja* includes six species of cedar native to Asia and North America. Through widespread plantings its range has been greatly extended as an exotic--particularly in Europe. The six recognized species are: *Thuja occidentalis* L., a native of northeastern North America, *T. plicata* Donn (*T. gigantea* Nutt.), native to northwestern North America, *T. orientalis* L. from north and west China, *T. koraiensis* Nakai, a Korean species, *T. standishii* (Gard.) Carr. from Japan, and *T. sutchuenensis* Franch., a native of central China. Several varieties have been described for the first three species of *Thuja* named above but none for the last three.

Knowledge concerning the six recognized species varies considerably. *T. koraiensis* is a rare species that is little cultivated and *T. sutchuenensis*, first described in 1899, is not in cultivation. Little is known about the diseases of these species. The other four species have been extensively planted as ornamentals and are therefore widely known. *T. plicata* has been planted in several countries as a promising timber species. In Britain, plantations dating back to 1876 are now producing trees of commercial size. Throughout their native range both *T. plicata* and *T. occidentalis* are important timber species.

Cedar wood is light, soft, brittle, fragrant, quite durable, and easily worked. The sapwood is usually paler than the heartwood. Cedar is used for making shingles, poles and posts of all kinds, siding for houses, boats, and in cooperage. The durability of this wood in contact with soil is greater than that of most other timber species.

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden, Utah

Present and Potential Disease Impact

Diseases caused by heart- and sap-rotting fungi are not of major importance. Root-rotting fungi have not been extensively studied, but it is known that they vary in importance from locality to locality. Probably the most damaging disease is cedar leaf blight caused by the fungus *Didymascella thujina* (Durand) Maire.[3] It often kills seedlings in one or two seasons; even saplings and older trees may be severely retarded but are not often killed. This fungus was originally confined to *T. plicata* in North America, but spread to *T. occidentalis*. It has been found in *Thuja* seed and seed infection is probably the chief means by which the fungus has spread into Europe and other areas from its native range.

In this disease, the infected leaf twigs first appear brownish and then drop in late autumn. The blackish, cushionlike apothecia are usually present on the upper surface of the leaves. However, on leaves remaining attached to older twigs the apothecium drops out, leaving a characteristic deep pit. On older trees the disease is found most frequently on the lower branches near the ground. The host range of this foliage blight has expanded to other widely planted cedars, and its capabilities for further spread to cedars, wherever they are planted, seem great.

Other diseases are known to be destructive locally, but generally the problems that are encountered following the introduction of *Thuja* species into new regions are not serious.

SEEDLING DISEASES

This group of diseases may well be the most important potential source of trouble. The leaf blight of cedar caused by *Didymascella thujina* is the most destructive disease of *Thuja* species throughout the world. *Pestalotia funerea* and *Phomopsis juniperovora* are also widespread, but are somewhat less destructive than *D. thujina*. In addition, a number of damping-off diseases and needle blights are of local significance. Introduction of almost any one of these diseases into new areas could result in appreciable damage. Control in nurseries usually employs fumigants and copper-based sprays.

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3 *Keithia thujina* Durand is a later synonym incorrectly used by many authors.

Causal organism and type of damage	Reported from:
Botrytis cinerea Pers. ex Fr. Gray mold blight	U.S.A.
Cercospora thujina Plakidas Blight	U.S.A.
Cladosporium herbarum (Link) Fr. Black mold	China
Coryneum berckmanii Mil. Tip blight	U.S.A.
Didymascella thujina (Durand) Maire Leaf blight and dieback	Canada, Denmark, England, Italy, Norway, U.S.A.
Fusarium oxysporum Schlecht Damping off	U.S.A.
Fusarium oxysporum Schlecht var. aurantiacum (Lk.) Wr. Damping off	Germany
Fusarium roseum Sacc. Damping off	U.S.A.
Fusarium solani (Mast.) Appel & Wr. Damping off	Belgium
Helicobasidium mompa Tanaka Violet root rot	Japan
Pestalotia funerea Desm. Blight	Belgium, Germany, Gt. Brit. Italy, U.S.A., U.S.S.R.
Pestalotia spp. Blight	U.S.A.
Phacidium abietis (Dearness) Reid & Cain Snow blight	U.S.A.
Phomopsis juniperovora Hahn Dieback	Denmark, France, Mozambique, Netherlands, New Zealand
Phymatotrichum omnivorum (Shear) Dug. Cotton root rot (serious in Texas)	U.S.A.
Phytophthora cinnamomi Rands Seedling root rot	Argentina, U.S.A.

Pythium debaryanum Hesse — U.S.A.
Damping off

Rhizoctonia solani Kuehn — U.S.A.
Damping off

Thelephora terrestris Fr. — U.S.A.
Smothering disease of seedling stems

ROOT DISEASES

All of the root disease fungi listed could create problems in ornamental, shelterbelt, or forest plantings. Armillaria mellea and Fomes annosus are distributed most widely and probably provide the greatest potential threat to plantings in new areas. However, both Clitocybe tabescens and Poria weirii are potentially dangerous, and care should be taken to avoid introducing them into new areas. In nursery beds and ornamental plantings, soil may be fumigated prior to planting. Root fungi in forest stands present a more difficult problem. Direct control is not now possible. Sanitation cutting and treating stumps and dead material with chemicals have restricted the spread of root fungi in some instances.

Causal organism and type of damage	Reported from:
Armillaria mellea (Fr.) Quél. Shoestring root rot	Canada, England, Finland, Sweden, U.S.A.
Clitocybe tabescens (Scop. ex Fr.) Bres. Root rot	U.S.A.
Fomes annosus (Fr.) Karst. Spongy root rot	Canada, Gt. Brit., U.S.A.
Polyporus schweinitzii Fr. Red-brown butt rot	Canada, Denmark, U.S.A.
Phymatotrichum omnivorum (Shear) Dug. Cotton root rot (serious in Texas)	U.S.A.
Poria weirii Murr. Yellow ring rot	Canada, U.S.A.

STEM DISEASES

Several stem and branch cankers are reported, but only the branch canker caused by Coryneum cardinale seems potentially capable of

causing any problem. Caeoma deformans, which causes witches'-brooms, is the only rust of any importance. Heart and sap rots cause considerable damage. The principal decay organisms are Fomes pini, Polyporus balsameus, Poria albipellucida, P. asiatica, P. subacida, and P. weirii. Control is usually indirect and consists of sanitation cuttings and removal of infected material.

Several of these diseases have been reported on a single species of Thuja. Additional knowledge of the host specificity of these diseases and their distribution is needed. When this information is available, diseases can be singled out as truly endemic to a specific region and measures taken to prevent their spread.

Stem Cankers

Causal organism and type of damage	Reported from:
Coryneum cardinale Wagener, W. W. Twig canker	U.S.A.
Coryneum juniperinum Ell. Twig canker	U.S.A.
Coryneum thujinum Dearn. Twig canker	U.S.A.
Coniothyrium albistratum (Pk.) Sacc. Stem canker	Europe
Cytospora dubyi Sacc. var. thyophila Sacc. Branch canker	U.S.A.
Cytospora thujae Sacc. & Ell. Branch canker	U.S.A., U.S.S.R.
Diplodia pinea (Desm.) Kickx Canker and twig blight	Portugal
Trichoscyphella hahniana (Seaver) Nannt. Canker	Germany
Valsa abietis Fr. Canker	Japan, U.S.A.
Valsa kunzei Fr. Canker	U.S.A.
Valsa thujae Pk. Canker	U.S.A.

Valsa thujae Pk. var. *foliicola* Ell. & Ev. Canker	U.S.A.
Valsa weiriana Petrak Canker	U.S.A.
Valsa spp. Canker	Japan

Rusts

Caeoma deformans (Berk. & Br.) Tub. Witches'-broom	Japan

Sap Rots and Heart Rots

Causal organism and type of damage	Reported from:
Chaetomium funicola Cooke Brown sap rot	U.S.A.
Ceratocystis piceae (Münch) Bakshi Blue stain of living sapwood	Europe, Japan, U.S.A.
Coniophora puteana (Schum. ex Fr.) Karst. Brown cubical rot	Canada, Gt. Brit., U.S.A.
Echinodontium tinctorium (Ell.) Ell. & Ev. Brown stringy rot	U.S.A.
Fomes annosus (Fr.) Karst. Spongy sap rot	Canada, Gt. Brit., U.S.A.
Fomes applanatus (Pers. ex Wallr.) Gill. White mottled butt rot	U.S.A.
Fomes pini (Fr.) Lloyd Red ring rot	Canada, U.S.A.
Fomes pinicola (Fr.) Cke. Brown trunk rot	U.S.A.
Fomes roseus (Fr.) Karst. Brown trunk rot	U.S.A.

Hormodendrum microsporum Lagh. & Melin Blue stain of heartwood	U.S.A.
Paxillus panuoides (Fr. ex Fr.) Fries Brown sap rot	U.S.A.
Polyporus anceps Pk. White pocket rot	U.S.A.
Polyporus balsameus Pk. Brown cubical butt rot	Canada, U.S.A.
Polyporus cuneatus (Murr.) Zeller Sap rot	Canada, U.S.A.
Poria albipellucida Baxter White ring rot	Canada, U.S.A.
Poria asiatica (Pilát) Overh. Brown cubical rot	Canada, U.S.A.
Poria ferruginosa (Schrad. ex Fr.) White rot of dead wood and bark	Canada, U.S.A.
Poria ferruginofusca Karst. White rot	Canada, U.S.A.
Poria subacida (Pk.) Sacc. Spongy root rot	U.S.A.
Poria weirii Murr. Yellow ring rot	Canada, U.S.A.

FOLIAGE DISEASES

As a group, few of the foliage diseases are of any importance; only three diseases seem worthy of comment: leaf blight of cedar caused by Didymascella thujina, tip blight caused by Coryneum berkmanii, and twig blight caused by Pestalotia funerea. Control can usually be attained by applying Bordeaux mixture or other copper sprays in the fall.

Causal organism and type of damage	Reported from:
Botrytis cinerea Pers. ex Fr. Gray mold blight	U.S.A.
Chloroscypha seaveri (Rehm) Seaver Leaf blight	U.S.A.

Cladosporium herbarum (Lk.) Fr. Black mold	China
Coryneum berkmanii Mil. Twig blight	U.S.A.
Coryneum thujinum Dearn. Twig blight	U.S.A.
Diplodia atthiana Allesch. Dieback	Europe
Diplodia thujae West Dieback	Europe
Diplodia pinea (Desm.) Kickx Dieback	Portugal
Didymascella (Keithia) thujina (Durand) Maire Leaf blight	Belgium, Canada, Denmark, Gt. Brit., Italy, Norway, U.S.A.
Gymnosporangium biseptatum Ell. Rust	Europe
Helotium thujinum Pk. Twig blight	Europe
Lophodermium thujae J.J. Davis Needle spot	Japan, U.S.A.
Mycosphaerella canadensis (Ell. & Ev.) Johns. Leaf spot	Europe, U.S.A.
Mycosphaerella thujae Petrak Leaf spot	U.S.A.
Pestalotia funerea Desm. Leaf blight	Belgium, Germany, Gt. Brit., U. S. A.
Phoma thujina Thuem. Leaf blight	Europe
Phomopsis occulta (Sacc.) Trav. Twig blight	U.S.A.
Rhabdospora orientalis Togashi & Tsukamoto Dieback	Japan

DISEASES OF TSUGA[1]

by

James W. Kimmey[2]

Tsuga (the hemlocks) is a genus of conifers native to temperate areas of North America and Asia only. However, the hemlocks have been planted in many parts of the world as exotic ornamentals and to a lesser extent as commercial forest trees.

Four species are indigenous to North America: *Tsuga canadensis* (L.) Carr. and *T. caroliniana* Engelm. in the East, and *T. heterophylla* (Raf.) Sarg. and *T. mertensiana* (Bong.) Carr. in the West. Japan has two native species: *T. diversifolia* (Maxim.) Mast. and *T. sieboldi* Carr. *T. chinensis* (Franch.) Pritz. and *T. yunnanensis* (Franch.) Mast. are native to China. Two species, *T. formosana* Hayata and *T. dumosa* (D. Don) Eichl., are indigenous to Taiwan and to the Himalayas, respectively.

Importance of the Genus

In their native ranges, six species of hemlock may be classed as timber-producing trees. *Tsuga heterophylla* is the most important of these commercially because of its size (it may grow 250 feet tall and 6 to 10 feet in diameter) and the superior quality of its wood in comparison to that of other hemlocks. *T. canadensis* and *T. mertensiana* are also timber producers in North America. The latter, however, is commercially important in Alaska only--and on the Kenai Peninsula in particular. The two Japanese hemlocks and *T. chinensis* are timber-producing species in the Orient.

In their native habitats the hemlocks are valued for watershed cover and for esthetic reasons. These evergreens are unusually attractive, especially in their upper elevational ranges, and

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1 For distribution at FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forestry Sciences Laboratory, Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Moscow, Idaho

therefore are planted extensively as ornamentals. Many ornamental varieties of the hemlocks have been developed by commercial plant propagators mainly in Europe and the Orient. Some species, notably *Tsuga heterophylla*, are also planted as exotics for commercial forest crops, principally in Europe.

Hemlock wood is used for pulp and lumber, and to a lesser extent for construction timbers and veneer. The bark contains 7 to 12 percent tannin and has in the past been extensively used in the leather tanning industry.

Present and Potential Disease Impact

In their native ranges hemlocks are subject to heart rots but otherwise are unusually free of severe diseases that plague other coniferous forest trees--especially diseases that are known to be serious threats if introduced to other countries or continents. Widespread planting of hemlocks in arboreta, plant collections, and as ornamentals throughout much of the world has made them potentially dangerous as carriers of diseases to other tree species. A disease of little consequence to hemlock in its native habitat could become devastating, particularly to a different tree host on another continent.

In Great Britain the use of *Tsuga heterophylla* as a timber tree is severely restricted by *Fomes annosus* (Fr.) Cke., which causes twice as much decay in this species as it does in other tree species there. *T. heterophylla* is not planted in Britain on sites where this pathogen is known to be present or on sites that have been occupied by conifers for more than 40 years. *F. annosus* is the principal cause of heart rot only in the wetter part of the native range of this hemlock; in the drier part, other heart rots cause more damage than does this fungus.

Potentially, the disease most dangerous to hemlocks is probably the root rot caused by *Poria weirii* Murr. This fungus is known to attack *Tsuga diversifolia* and *T. heterophylla*, and numerous other conifers; it might become epiphytotic under new host and climatic conditions.

A form of the western dwarfmistletoe, which causes serious damage to native stands of *T. heterophylla*, might become a much more serious parasite if introduced to a continent where this host is planted as a timber tree. However, because of the host specificity of this parasite it is unlikely that other tree species--particularly other genera--would be seriously damaged by it.

No vascular wilts, systemic diebacks, or stem rusts have been reported on the hemlocks. However, intensive disease survey has

been confined to only two species: Tsuga heterophylla and T. canadensis. The other two North American species and the two Japanese species have received some attention, but little disease survey has been done on the remaining four species. Because intensive search has not been conducted for diseases on most hemlock species, the host species are not listed for the causal organisms. Most of these pathogens also attack trees of other genera; therefore, they may have a much wider distribution than that shown in the following lists, which include only those pathogens reported to cause serious damage to Tsuga.

SEEDLING DISEASES

No seedborne diseases have been reported for Tsuga. However, seedlings in even the earliest stages of germination are susceptible to diseases. Damping-off damage may be minimized through the use of well-ventilated seedbeds and soil acidifiers; heavy or excessively wet soils should be avoided. Soil sterilization with methyl bromide, formaldehyde, chloropicrin, or other materials may control some pathogens such as Pythium. When disease appears in nursery beds, spraying with compounds such as Bordeaux mixture or Burgundy mixture often effects satisfactory control. However, pathogens listed here must be considered potentially dangerous under particularly favorable conditions.

Causal organism and type of damage	Reported from:
Botrytis cinerea Pers. ex Fr. Twig blight	Gt. Brit., U.S.A.
Cephalosporium sp. Wilt dieback	Canada, U.S.A.
Corticium vagum B. & C. Damping-off	Belgium, U.S.A.
Cylindrocladium scoparium Morg. Root rot	U.S.A.
Fusarium spp. Damping-off	Belgium, U.S.A.
Fusoma parasiticum Tub. Damping-off	Germany
Melampsora farlowii (Arth.) Davis Needle rust	U.S.A.

Phacidium infestans Karst. Snow blight	U.S.A.
Phomopsis juniperovora Hahn Blight	U.S.A.
Pythium debaryanum Hesse Damping-off	U.S.A.
Rhizina undulata Fr. Root rot	Germany, U.S.A.
Rhizoctonia solani Kuehn Damping-off	Cosmopolitan
Rosellinia herpotrichioides Hepting & Davidson Grayish-brown felt smothering blight	Japan, U.S.A.
Rosellinia necatrix (Hart.) Berlese White root rot	Japan
Thelephora caryophyllea Schaef. ex Fr. Smothering fungus growth	U.S.A.

ROOT DISEASES

Aboveground symptoms of root diseases are often similar to those caused by other diseases; therefore, careful diagnosis is usually required accurately to determine their cause. Root diseases are less prevalent in natural stands of hemlock than in plantations, particularly when plantings are not adapted to the site or are of unnatural composition. Chemical control is generally impractical over extensive areas, but soil fumigation is sometimes effective in limited areas. Soil injection of carbon disulfide may start or stimulate biological control of some fungi such as Armillaria mellea (Fr.) Quél. In Great Britain Fomes annosus is the most troublesome disease of hemlocks. The best control there has been achieved through careful selection of planting sites. Poria weirii is potentially dangerous in introduced planting stock from U.S.A., Canada, or Japan. Many conifers are susceptible to this serious root disease.

Causal organism and type of damage	Reported from:
Armillaria mellea (Fr.) Quél. Shoestring root fungus	Canada, Gt. Brit., Japan, New Zealand, U.S.A., including Alaska

Fomes annosus (Fr.) Cke. Spongy white rot of roots	Canada, Gt. Brit., Norway, U.S.A., including Alaska
Phymatotrichum omnivorum (Shear) Dug. Root rot accompanied by brown mycelial strands	U. S. A.
Polyporus dryadeus Pers. ex Fr. White root rot; weeping conk. May kill trees by decaying sapwood and killing cambium at root crown	U. S. A.
Polyporus tomentosus Fr. (Including *Polyporus tomentosus* var. *circinatus* (Fr.) Sartory & Maire) White pocket root rot; kills trees	Canada, U. S. A.
Poria sericeomollis (Rom.) Egel. (*P. asiatica* (Pilát) Overh.) Root and butt rot	Canada
Poria subacida (Pk.) Sacc. Soft spongy white rot of roots; white or yellow conks	Canada, Japan, U. S. A.
Poria weirii Murr. Yellow ring rot. Severe root and tree killer. Brown conks	Canada, Japan, U. S. A.
Rosellinia necatrix (Hart.) Berlese White rot of roots	Japan

STEM DISEASES

The most severe losses from stem diseases are caused by the heart rots, although dwarfmistletoe causes considerable loss by reducing the growth rate of infected trees. Dwarfmistletoe is most prevalent as a branch disease, as are most other canker-causing diseases. Cankers may cause severe damage to saplings or pole-size trees when stems are affected. However, canker diseases seldom cause serious losses in plantations or natural stands. No stem rusts have been reported on *Tsuga*.

Cankers and Diebacks

Causal organism and type of damage	Reported from:
Aleurodiscus amorphus (Pers. ex Fr.) Rab. Elliptical canker; centers around a dead branch	U.S.A.
Botrytis cinerea Pers. ex Fr. Dieback; on current season's shoots	U.S.A.
Botrytis sp. Twig blight	U.S.A.
Cephalosporium sp. Canker occurs annually on stem of suppressed trees	Canada, U.S.A.
Cytospora sp. Twig canker; may be *C. curreyi* Sacc.	U.S.A.
Dasyscyphus agassizii (Berk. & Curt.) Sacc. Canker on branches; white apothecia	U.S.A.
Dasyscyphus aridus (Phil.) Sacc. Kills small stems and branches; yellow apothecia	U.S.A.
Dermatea balsamea (Pk.) Seaver Canker twig blight	U.S.A.
Dermatea sp. Canker	Canada
Fomes robustus Karst. (*Poria tsugina* Murr. ex Sacc. & Trott.) White heart and sap rot; kills cambium	Canada, U.S.A., including Alaska
Hymenochaete agglutinans Ell. Canker	U.S.A.
Phacidiopycnis pseudotsugae (Wilson) Hahn. (*Phomopsis pseudotsugae* Wilson) Stem canker	Gt. Brit. to Czechoslovakia - general
Phomopsis occulta Trav. Twig blight	U.S.A.

Phomopsis sp. Canker	Canada
Tympanis tsugae Groves Canker	Canada
Valsa abietis Fr. Dieback	U.S.A.

Heart Rots

Not all fungi reported as causing decay of hemlock wood are reported here. Only those fungi that cause significant amounts of decay in living trees are listed.

Causal organism and type of damage	Reported from:
Armillaria mellea (Fr.) Quél. White spongy butt rot	Canada, Gt. Brit., Japan, U.S.A., including Alaska
Coniophora puteana (Schum. ex Fr.) Karst Brown cubical rot	Canada, U.S.A.
Corticum galactinum (Fr.) Burt. Stringy yellow butt rot	Canada
Flammula alnicola (Fr.) Kummer Yellow stringy rot	Canada
Echinodontium tinctorium Ell. & Ever. Rust-red stringy rot; most prevalent in warm climates	Canada, Japan, U.S.A.
Fomes annosus (Fr.) Cke. Spongy white rot; most prevalent in cool climates	Canada, Gt. Brit., Norway, U.S.A., including Alaska
Fomes applanatus (Pers.) Gill. White mottled butt rot	Canada, U.S.A., including Alaska
Fomes officinalis (Vill. ex Fr.) Faull Brown cubical trunk rot	Canada, U.S.A.
Fomes pini (Thore) Lloyd Red ring rot; small white pockets	Canada, China, U.S.A., including Alaska
Fomes pinicola (Sw.) Cke. Brown cubical rot	Canada, India, Japan, U.S.A., including Alaska

Fomes robustus Karst. (Poria tsugina Murr. ex Sacc. & Trott.) White trunk rot; decays living sapwood as well as heartwood	Canada, Japan, U.S.A., including Alaska
Ganoderma lucidum (Leyss. ex Fr.) Karst. Spongy white butt rot	U.S.A.
Ganoderma oregonense Murr. White spongy root and butt rot	Canada, U.S.A.
Ganoderma tsugae Murr. Soft wet white rot	Japan, U.S.A.
Hydnum abietis Hubert (Hericium sp.) Long pitted white rot	Canada, U.S.A.
Odontia bicolor (Alb. & Schw. ex Fr.) Bres. White butt rot	Canada
Omphalia campanella Fr. Brown rot	Canada
Pholiota adiposa (Balsch ex Fr.) Kummer White trunk rot	Canada, U.S.A., including Alaska
Polyporus abietinus Dicks. ex Fr. White rot; principally of dead sapwood	Canada, U.S.A.
Polyporus anceps Pk. White pocket rot	U.S.A.
Polyporus balsameus Pk. Brown butt rot	U.S.A.
Polyporus fibrillosus Karst. Brown rot	Canada
Polyporus schweinitzii Fr. Brown cubical butt rot	Canada, U.S.A., including Alaska
Polyporus sulphureus (Bull.) Fr. Brown butt and trunk rot	Canada, Japan, U.S.A., including Alaska

Polyporus tomentosus Fr. White root and butt rot	Canada
Poria albipellucida Baxter White trunk rot	Canada, U.S.A.
Poria cocos (Schw.) Wolf Brown root and butt rot	Canada
Poria nigrescens Bres. Brown fibrous rot	Canada
Poria subacida (Pk.) Sacc. (P. colorea Overh. & Englerth) Soft spongy white root and butt rot	Canada, Japan, U.S.A.
Poria weirii Murr. Yellow ring rot	Canada, Japan, U.S.A.
Stereum abietinum Pers. Brown cubical pocket rot	Canada
Stereum chailletii Pers. ex Fr. White rot	Canada, U.S.A.
Stereum sanguinolentum (Alb. & Schw. ex Fr.) Fr. White pocket rot	Alaska, Canada, China

Dwarfmistletoes

Arceuthobium campylopodum Engelm. f. tsugensis (Rosendahl) Gill	Canada, U.S.A., including Alaska

FOLIAGE AND CONE DISEASES

No particularly severe foliage diseases of Tsuga have been reported. However, relatively few of the native foliage diseases have been introduced to plantings or to native Tsuga species in foreign lands. Damage from foliage pathogens is serious in nurseries and ornamental plantings; but direct control using fungicides usually is practical in these situations. Control in forest stands has not been warranted, therefore no control measures have been developed.

Causal organism and type of damage	Reported from:
Acanthostigma parasiticum (Hart.) Sacc. Needle blight on trees of all ages	Gt. Brit., Germany
Aecidium tsugae Sawada Needle rust	Japan
Ascochyta conicola Dearn. & House Necrosis on cones	U.S.A.
Balladynella tsugae Batista Needle discoloration	U.S.A., including Alaska
Chrysomyxa tsuga-yunnanensis Teng (C. tsugae Hiratsuka) Needle rust-III	China, Japan
Didymascella tsugae (Farl.) Maire (Keithia tsugae Farl. ex Durand) Needle blight	Scotland, U.S.A., including Alaska
Dimerosporium tsugae Dearn. Sooty mold; black crusty spots on needles	U.S.A.
Gelatosphaera tsugae Batista & Maia Black mold on needles and twigs	U.S.A., including Alaska
Herpotrichia nigra Hartig Brown felt smothering blight	U.S.A., including Alaska
Melampsora abietis-canadensis (Farl.) Ludw. Needle and cone rust - 0 and I Subcuticular pycnia	U.S.A.
Melampsora epitea Thüm. f. sp. tsugae Ziller Needle rust - 0 and I Subepidermal pycnia	Canada, U.S.A.
Melampsora farlowii (Arth.) Davis Needle and cone rust - III	Canada, U.S.A., including Alaska
Micropera sp. Necrosis on needles	U.S.A.
Neopeckia coulteri (Pk.) Sacc. Brown felt blight	U.S.A.

Phacidium infestans Karst. Snow blight	U.S.A.
Phacidium tsugae Cash & Davidson Needle blight	U.S.A.
Phaeocryptopus nudus (Pk.) Petr. (*Adelopus nudus* Pk. ex Hoehn) Needle cast	Japan, U.S.A.
Pucciniastrum hydrangeae (Berk. & Curt.) Arth. Needle rust - O and I	U.S.A.
Pucciniastrum myrtilli (Schum.) Arth. (*P. vaccinii* (Wint.) Jorstad) (*Thecospora vacciniorum* Karst.) Cone and needle rust - O and I	U.S.A., including Alaska
Rosellinia herpotrichioides Hepting & Davidson Grayish-brown felt smothering blight	Japan, U.S.A.
Uraecium holwayi Arth. Needle rust - I	U.S.A., including Alaska

DISEASES OF EUCALYPTUS [1]

by

Giorgio Magnani[2]

The Eucalyptus family numbers more than 600 species and varieties, differing in their dimensions (one passes from certain dwarfed species to others, that are among the largest giants of the plant kingdom); in the appearance of their foliage (which varies in color, size and position of the leaves; there are even some species with deciduous leaves, for example, "*E. brachyandra*") and of their bark (there is a whole range of bark-types); in their aromatic emanations (often perceptible at some distance); also in the degree of their compatibility.

The Eucalyptus are plants of Australian origin, which have been widely introduced to different countries, to be cultivated in regions characterized by temperate-warm climates.

The following are the most cultivated Eucalyptus species in the world:

E. camaldulensis Dehn
E. globulus Labill
E. saligna Sm.
E. tereticornis Sm.
E. viminalis Labill
E. robusta Sm.
E. resinifera Sm.
E. citriodora Hook

Other species of importance are: *E. botryoides* Sm., *E. maidenii* F.v.M., and furthermore *E. diversicolor* F.v.M., *E. sideroxylon* (A. Cunn.) Benth., *E. gomphocephala* A.DC., *E. maculata* Hook, *E. grandis* (Hill) Maiden, *E. paniculata* Sm.

E. camaldulensis. This is the most widely cultivated species in the world. The best growth is obtained in very deep alluvial

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Centro di Sperimentazione Agricola e Forestale, Ente Nazionale per la Cellulosa e per la Carta, Rome, Italie

soils, but even sandy soils are favorable, provided their lower layers are fresh. It prefers regions with modest rainfall (annual precipitations 250 to 650 mm) and its resistance to cold is satisfactory. It is suitable for wind breaks and forest plantations, and its wood is utilized for poles, posts, pulp and fuel.

E. globulus. This species develops in rather heavy soils of good quality, but not too wet. It prefers regions with annual precipitation between 500 and 1,500 mm. Its resistance to cold is inferior (in its early stages) to that of the E. camaldulensis. Its very hard wood is used for the construction of houses and boats as well as for fuel.

E. saligna. It grows well in soils of clayey type, fresh and not subject to dryness. It prefers regions with large summer precipitation (yearly precipitation between 1,000 and 1,500 mm.) and temperatures of subtropical type. Its rather hard wood is used for the manufacturing of furniture and in the construction industry.

E. tereticornis prefers alluvial or clayey-sandy soils, annual precipitation between 500 to 1,500 mm., with large summer rainfall, and a warm-temperate to subtropical climate. This species is utilized for reafforestation, while its wood is used for the construction of houses and bridges as well as for railroad ties (sleepers).

E. viminalis grows in soils of moderate quality, but especially in sandy soils. It prefers a subtropical to temperate climate, with yearly precipitation from 650 to 1,400 mm. It is utilized for reafforestation, and its wood is used as saw timber of inferior quality and as fuel.

E. robusta develops in heavy soils, but also in other soils, provided they are fresh. It prefers regions with humid summers, with annual precipitation between 1,000 and 1,500 mm. Its wood is utilized in the construction industry.

E. resinifera. Although the best growth is obtained in deep and fertile soils, the development is nevertheless rather good in other soils, provided they are well drained. It prefers a humid semi-tropical climate with annual precipitation from 1,250 to 1,500 mm. This species is used for reafforestation and wind breaks. Its wood is utilized in the construction industry.

E. citriodora develops in a wide range of soils, but ordinarily in rather poor sandy soils. It prefers a tropical to subtropical climate, with annual precipitation from 650 to 1,000 mm. This species is utilized for forest plantations and its wood for lumber.

E. botryoides prefers wet, clayey soils and a humid temperate climate, not too cold. It is utilized for reafforestation and its wood is used in house construction. Another species to be mentioned is *E. maidenii*, which grows in soils of average quality and in temperate cool climates. Its wood is utilized for general construction.

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The phytopathological literature describes different Eucalyptus diseases, of which only a few however, cause severe damage, with the majority causing local injuries only and not affecting the life of the tree. According to the age of the plant and the part attacked, the diseases caused by fungi have been subdivided in the following manner:

SEEDLING DISEASES

In the nursery, the very young trees are often subject to a well known disease, described by Anglo-American authors under the name of "damping-off." This disease develops and spreads relatively easily because of the favorable environment and the delicate tissues of the host. Infected seedlings wilt and break off or fall over at the root collar.

Consequently, one should use preventive measures and treatments to protect the plants in an adequate manner. It is advisable to treat the seeds with Granosan M* or with Neantina dry (PMA) (for both products: 200 grams per 100 kilogram of seeds), in order to obtain protection until germination. One can also pulverize Thylate* on the soil, the first time immediately after seeding and afterwards two more times, at intervals of one week.

The use of commercial formalin should also be considered, diluted in water to 2.5%, for disinfecting the frames and the soil of the seedbed (on bare soil, apply a ratio of 10 litres per m^2, cover the ground afterwards with paper for 2 or 3 days, and finally turn the soil over and wait several days before seeding). After germination, in case of need, the plants should be protected by pulverized Orthocide.* It is also recommended to renew the soil in the seedbed.

Botrytis spp. Damping-off

Well known in Brazil, Kenya and Japan on *Eucalyptus* sp. It is responsible for serious losses in the seedbed.

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* Granosan (organic salt of mercury), Thylate (Thiram), Orthocide (Captan).

Cylindrocladium sp. Damping-off

Well known in Brazil on E. citriodora, E. alba and E. tereticornis.

Cylindrocladium scoparium Morg. Damping-off

Well known in Argentina on E. globulus, E. cinerea, etc.; in Brazil (it appears that this disease is the most important one in the state of Sao Paulo); in Japan on E. citriodora, E. coccifera, E. gigantea, E. globulus, E. gunnii, E. longifolia, E. obliqua, E. pauciflora, E. regnans, E. resinifera, E. robusta, E. saligna, E. tereticornis, E. viminalis.

Cylindrocladium scoparium Morg. Damping-off
var. brasiliensis Batista & Ciferri

Well known in Brazil, on Eucalyptus sp. Causes serious losses in seedbeds.

Phytophthora sp. Damping-off

Well known in Argentina on Eucalyptus sp. Causes serious losses in the seedbeds.

Phytophthora cinnamomi Rands Root rot

Well known in Australia on Eucalyptus spp. Frequently causes serious losses.

Pythium sp. Damping-off

Well known in Australia, Argentina and Japan on Eucalyptus spp. Is the cause of serious destruction in nurseries, at least in the two last-named countries.

Rhizoctonia sp. Damping-off

Causes rotting of roots of Eucalyptus spp. in Palestine and serious damage in the nurseries of Argentina.

ROOT DISEASES

Root diseases generally cause the death of infected trees, not only because of the virulence of the pathogen but also because of unfavorable factors in the environment and of difficulties in carrying out protective measures. Studies concerning the treatment of the roots by fungicides are in progress at the present time; there has to be considered, however, that the plants are attacked less easily by these diseases, when they are strong.

Armillaria mellea (Fr.) Quél. Root rot

Well known in Australia on Eucalyptus calophylla and Eucalyptus spp.; in Kenya on Eucalyptus spp.; in the Republic of South Africa on E. paniculata; in Tanganyika on E. citriodora and E. globulus; and in Italy (by author of this report) on E. camaldulensis. This disease strikes plants of all ages, and its appearance is often in keeping with pedologic unfavorable conditions (stagnation of water, density of soil, etc.)

Botryosphaeria ribis (Fr.) Gross. & Dug. Root rot

Well known in Argentina, where it causes death by decaying the roots and root collar of Eucalyptus plants from 7 to 8 years old. It is recommended to expose the roots at a depth and width according to age and height of the plant to prevent infection in poorly-drained soils.

Clitocybe tabescens Bres. Root rot

Well known in U.S.A. and in Spain, where it is very frequent.

Ganoderma colossus (Fr.) Baker Root rot

Well known in the Republic of South Africa on E. citriodora, E. maculata, E. punctata, E. paniculata.

Rhizoctonia bataticola (Taub.) Butl. Root rot

Well known in Ceylon and in Rhodesia and Uganda.

Rosellinia sp. Root rot

Known in Portugal, in one Eucalyptus plantation. The infection appeared serious, and in fact 50% of the subjects were attacked. This parasite can cause the death of diseased plants.

Rosellinia radiciperda Mass. Root rot

Known in New Zealand. Plants growing on sites with stagnant water are subject to this disease, but it does not appear on well tended and cultivated terrains.

STEM AND BRANCH DISEASES

This group includes diseases affecting the bole and branches of trees of all ages, from one-year seedlings to maturity.

Botryosphaeria berengeriana de Not. Withering (dieback)

Well known in Portugal, on E. globulus. The parasite occurs in a perfect stage (B. berengeriana) and an imperfect stage with two forms: macro- and micro-pycnidia (Dothiorella vulgaris Trav. and D. berengeriana Sacc.). The attacked plants, between 3 and 6 years old, show the characteristic symptoms of withering.

Botryosphaeria ribis var. chromogena Shear, Stevens & Wilcox Dieback

Well known in the Hawaian Islands. It is more pathogenic and more damaging than the preceding fungus.

Botrytis sp. Stem canker

Well known in Portugal, on E. globulus in seedbeds and young plantations, where it causes death of 5 percent of the subjects. Also known in Spain.

Botrytis cinerea Pers. — Stem canker

Well known in New Zealand on *E. gigantea*; in Brazil on *E. citriodora*, *E. botryoides*, *E. alba*; in Argentina on *E. alba*, *E. botryoides*, *E. camaldulensis*, *E. citriodora*, *E. tereticornis*; in Italy on *E. globulus*, *E. bicostata*, and *E. maidenii*; and in Kenya on *E. globulus*. In general, this fungus appears first on the leaves and afterwards invades the bole, on which it causes cankers. High humidity and excessive density of plants in nursery seedbeds favor the spreading of this disease, which causes severe losses if treatments with fungicides are not carried out; it is advisable to apply Orthocide, from 0.3 to 0.4 percent.

Corticium salmonicolor Berk. & Br. — Stem and branch canker

Well known in the ex-Belgian Congo on *Eucalyptus* sp.; in Mauritius (in some zones) on *Eucalyptus* sp.; in Brazil on *E. alba*, two years of age, where it causes canker of the bole; and in India on *E. globulus* and *E. robusta*, on which it causes canker of the bole and branches. The infection is especially encouraged in wet surroundings.

Cylindrocladium scoparium Morg. var. *brasiliensis* Batista & Ciferri — Withering

Well known in Brazil on *Eucalyptus* sp.

Dothiorella berengeriana Sacc. and *D. vulgaris* Trav. — Withering

(See *Botryosphaeria berengeriana*)

Fomes fomentarius (Fr.) Kickx — Trunk rot

Known in Portugal on *Eucalyptus* sp. It causes a white rot of the wood.

Ganoderma colossum (Fr.) Bres. — Dry rot

Well known in the Republic of South Africa. This parasite is the cause of grave attacks on different *Eucalyptus* species, especially *E. maculata* and *E. paniculata*.

Macrophoma sp. — Brown rot

Well known in Ceylon on *E. globulus*.

Melanconium sp. — Branch canker

Well known in some regions of Argentina on small branches of *E. viminalis*.

Pholiota adiposa (Fr.) Quél. and *P. rufofulva* Clel. — Dry rot

Well known in two regions of Australia on the bole of *Eucalyptus* sp. The first of these parasites is the cause of grave dry rot.

Phytophthora parasitica Dast. Stem canker

Well known in Brazil on *E. citriodora* and in Argentina on *E. viminalis*, causing stem cankers of young plants.

Polyporus eucalyptorum Fr. Heart rot

Well known in Australia on *E. baxteri*, *E. camaldulensis*, *E. elaeophora*, *E. leucoxylon*, *E. marginata*, *E. obliqua*, and *E. viminalis*. It seems that this fungus is the greatest destroyer of *E. marginata* in West Australia.

Polyporus dryadeus Fr. White heart rot

Well known in Australia on *E. obliqua* and *Eucalyptus* sp.

Polyporus laetus White dry rot

Well known in Australia on *Eucalyptus* sp.

Polyporus sulphureus Fr. Trunk rot

Well known in U.S.A. on *E. globulus*, as the cause of extensive heart rot in the lower part of the trunk; in Argentina, on *E. globulus* and *E. amygdalina* at the base of the trunk of old trees; in Portugal on *Eucalyptus* sp. and in the Republic of South Africa on *Eucalyptus* sp.

Poria healeyi Walters Yellow dry rot

Well known in Australia on *E. marginata* and *E. regnans*.

FOLIAGE DISEASES

These diseases are of no practical importance and become serious only occasionally in nurseries. In any case, application of fungicides is sufficient to control these diseases.

Alternaria sp. Leaf spot

Well known in Portugal, especially on *E. globulus*. This disease can sometimes cause rapid defoliation.

Alternaria tenuissima (Fr.) Wilt. Leaf spot

Well known in Italy on numerous species, among them *E. botryoides*, *E. globulus*, *E. maidenii*, *E. bicostata* and *E. trabutii*. The disease causes small leaf spots surrounded by a red circle. In the nursery this disease can cause defoliation, almost always partial but very rarely total. Control of this disease, which is seldom serious, is difficult.

Botrytis cinerea Pers. Leaf spot and leaf roll

Well known in Brazil on *E. citriodora*, *E. botryoides* and *E. alba*; in Italy, on *E. globulus*. *E. bicostata* and *E. maidenii*; in Kenya on *E. globulus* and in Argentina on *E. rostrata*. This parasite

causes large brown leaf spots, from which it invades the young bole and causes bark cankers. Excessive density of plants should be avoided to encourage air movement. Fungicides such as Orthocide, 0.3 to 0.4 percent, are effective.

Calonectria theae — Leaf spot

Well known in Mauritius on Eucalyptus sp. Is the cause of serious attacks in the months of April and May, when the season is especially humid.

Cercospora epicoccoides Cke. & Mass. — Leaf spot

Well known in Australia on E. globulus; in Argentina on E. globulus and E. rostrata; and on Formosa on E. globulus. Causes spots with diameters of 2 or 3 mm, of red-purple color at the beginning and brown later.

Cercospora eucalypti Cke. & Mass. — Leaf spot

Well known in India on E. ficifolia; in Italy on E. globulus and E. rostrata; in Argentina on E. globulus and E. camaldulensis; in Brazil on E. globulus; in Formosa on E. globulus; and in Australia, in Peru and in ex-Belgian Congo on Eucalyptus sp. Causes brown spots with a diameter of several mm.

Cylindrocladium scoparium Morg. — Leaf spot

Well known in Argentina on E. cinerea and Eucalyptus sp. Produces spots of skin-color (grey on E. cinerea), roughly circular, with a diameter between 1.5 and 15 mm.

Cylindrocladium scoparium Morg. var. brasiliensis Batista & Ciferri — Leaf spot

Well known in Brazil on Eucalyptus sp. Causes irregular spots, in the beginning of a rouge-purple color, later of a darker color in the center and a dark red in the peripheral area. This fungus can cause defoliation.

Elsinoe eucalypti — Leaf spot

Well known in Brazil on Eucalyptus sp. Causes spots of a dark maroon color, larger than 4 mm in diameter.

Harknesia eucalyptina Aniceta Santos — Leaf spot

Well known in Portugal on E. globulus. This parasite manifests itself through the appearance of spots of a brown-wine color with a diameter of 3 mm. The leaf-stalks are also attacked and dry up, causing defoliation. Serious losses have been recorded.

Mycosphaerella molleriana Thuem. — Leaf spot

Well known in Rhodesia on E. maidenii; in Tanganyika on E. globulus; in Portugal and in U.S.A. on Eucalyptus spp. Causes maroon spots with a darker border.

Oidium sp. — White powdery mildew

Well known in Portugal on E. globulus; in Italy on E. camaldulensis, E. globulus, E. viminalis, E. botryoides and E. maidenii; in Argentina and Australia on Eucalyptus sp. Also well known in England and in Poland, on different plant species cultivated in greenhouses. It forms a whitish mould on the leaves, which covers the limb partially or totally. The leaves are wrinkled, blistered and often drop. The disease is favored by environmental conditions. Application of sulphur fungicides gives good control.

Oidium eucalypti Rostr. — White powdery mildes

Well known in Italy on E. rostrata and in Denmark on Eucalyptus sp. cultivated in greenhouses.

Pestalotia molleriana Thuem. — Leaf spot

Well known in Uruguay on E. obliqua, and in Portugal and France on Eucalyptus sp. Causes spots with a diameter of 1 or 2 cm. of maroon color with a red border.

Phyllosticta sp. — Leaf spot

Well known in the South African Republic on Eucalyptus sp. and in the Seychelles on E. citriodora.

Phyllosticta eucalypti Thuem. — Leaf spot

Well known in Denmark on E. gigantea and in U.S.A., Spain, USSR, Portugal, Algeria, and Australia on Eucalyptus sp. Causes spots of various colors, from dark maroon to light grey. When the attacks are severe, early defoliation results.

Puccinia psidii Wint. — Leaf rust

Well known in Brazil on E. citriodora. Attacks leaves and young stems, on which numerous fruiting bodies appear. This disease can render the plant unfit for recovery.

VASCULAR WILTS

Fusarium oxysporum f. eucalypti Arya & Jain — Wilt

Well known in India on the roots of E. gomphocephala. Symptoms are fading, withering and drying up of the foliage, as well as a cankering of the apical part of the roots. The mycelium is abundant in the xylem.

VIRUS

Well known in Argentina, on plants of E. propinqua, E. saligna, E. citriodora and E. maculata. Infected plants become chlorotic with reduced leaf development.

DISEASES OF POPULUS[1]

by

John G. Berbee

The genus Populus is divided into five sections. None of the species in the section Leucoides is of major importance. Some of the species in the section Turanga have some economic value in Africa and the Middle East but do not yet rate an important place among the poplars. These sections of the genus will not be considered further. The most important species in the remaining sections are given below with their approximate ranges.

A. SECTION LEUCE (ASPENS)

1. *Populus alba* L. White poplar. Natural range in southern, central and eastern Europe; western and central Asia. Widely introduced into other regions.

P. canescens Sm. is probably a hybrid between *P. alba* and *P. tremula* L.

2. *P. tremula* L. European aspen. Natural range primarily in Europe, central and northeast Asia.

3. *P. tremuloides* Michx. Quaking aspen. The range includes Alaska, Canada, the northern states of the United States east of the western prairie and the western coastal and Rocky Mountains from Canada to Mexico.

4. *P. grandidentata* Michx. Bigtooth aspen. This species occurs naturally in southern Canada and in northern United States from the Atlantic Coast to the western prairie.

5. *P. tremula* x *tremuloides*. This hybrid is cultivated in Europe, particularly in the Scandinavian countries.

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin, U.S.A.

B. SECTION AIGEIROS (BLACK POPLARS)

6. Populus deltoides Bartr. Eastern cottonwood. (Including P. angulata Ait., P. monilifera Henry and P. missouriensis Henry.) The natural range of this species extends across the eastern half of the United States and the contiguous part of southern Canada. P. deltoides has been introduced into Europe, Japan and other temperate regions. Other North American black poplars include: P. sargentii Dode and P. fremontii S. Wats.

7. P. nigra L. Black poplar. The range includes the southern third of Europe, Asia Minor and central Asia. Several varieties and cultivars are recognized. P. nigra, including several varieties, has been introduced into most of the temperate regions of the world.

8. P. x canadensis Moench. (P. x Euramericana (Dode) Guiner). Included here are natural and artificial hybrids between P. deltoides and P. nigra. Clones selected for cultivation from among these hybrids are economically important in central and southern Europe. Many of them have been distributed to the temperate regions of the world. The various cultivars are designated by a name or number following the binomial, viz., 'gelrica', 'robusta', 'serotina', 'marilandica', 'regenerata', 'eugenii', 'I-214'. In the literature, however, many of these well-known cultivars are designated by binomials, x P. gelrica for example. In this report, all of the forms included under P. x canadensis are treated as a single entity.

C. SECTION TACAMAHACA (BALSAM POPLARS)

9. P. trichocarpa Torr. & Gray. This species occurs naturally in western Canada and western United States, including Alaska.

10. P. balsamifera L. Balsam poplar. The range extends from Alaska over most of Canada and into northern United States. Included here is P. candicans Ait.

The Asiatic balsam poplars are considered in this report only on an incidental basis. Their economic importance is uncertain, but they have been used in breeding programs both in Europe and in North America. The following species appear frequently in the literature.

11. P. laurifolia Ledeb. Siberia.

12. P. suaveolens Fisch. Central Asia.

13. P. maximowiczii Henry. Japan.

14. *P. koreana* Rehd. Korea, Japan.

15. *P. simonii* Carr. China, Korea.

16. *P. yunnanensis* Dode. China.

17. *Tacamahaca* x *Aigeiros* hybrids.

    a) *P.* x *generosa* Henry = *P. deltoides angulata* x *P. trichocarpa*.

    b) *P.* x *berolinensis* Dippel., probably a hybrid between *P. laurifolia* and *P. nigra* var. *italica*.

IMPORTANCE OF THE GENUS

The poplars are among the leading commercial tree species of the world. Collectively, the aspens (section Leuce) extend across the northern part of the North Temperate Zone. They represent a major source of wood for pulp and also are used for lumber, veneer and various specialty products.

In northern Europe, aspen hybrids (*P. tremula* x *P. tremuloides*) are grown commercially because their growth is rapid and superior to that of either parent species.

Although the black poplars (section Aigeiros) have a more limited and southern range than the aspens, they are an important group in the genus. Some of them, especially *P. deltoides*, are valuable lumber and veneer trees because of their large size. For artificial culture, the black poplars have long been favored.

The European success with hybrids between *P. deltoides* and *P. nigra* has stimulated world-wide interest in poplar culture. More progress has been made in breeding poplars than in improving any other timber tree. Black poplar hybrids grow rapidly, produce woods that are suitable for many industrial uses, and can be selected for a variety of edaphic and climatic sites. They have proven most successful, however, in the southern part of the North Temperate Zone, particularly in southern and central Europe.

PRESENT AND POTENTIAL IMPACT OF DISEASES

A large number of different pathogens attack the various species of Populus. The native poplars within their natural ranges, however, generally are not severely damaged by them. There are, of course, many local exceptions. In old and overmature stands,

heart rots cause large losses but these can be avoided by regulating cutting cycles. Although often conspicuous and damaging locally, few, if any, of the endemic leaf and stem diseases preclude the successful commercial management of natural poplar stands. One of the most serious endemic diseases in natural stands is Hypoxylon canker of P. tremuloides in North America - a disease that causes a loss of approximately one per cent of the stands annually. The short rotation on which poplars are usually grown is an important factor in minimizing losses due to diseases.

There is abundant evidence, however, that diseases can threaten the poplar culture of entire regions. Plantations are particularly vulnerable. Many of them are comprised of very few clones, and sometimes of a single clone. Although much progress has been made in selecting clones for disease resistance, none of them is resistant to all of the poplar pathogens. In fact, some interspecific hybrids are highly susceptible to minor diseases of the parent species. Examples are the susceptibility of P. deltoides x P. balsamifera to Septoria canker caused by Mycosphaerella populorum Thompson and the vulnerability of certain hybrids between P. alba and P. grandidentata to shoot blight caused by Venturia populina (Vuill.) Fabr. Another risk factor in monoclonal culture is the possibility of an ubiquitous pathogen, such as Colletotrichum gloeosporioides Penz, becoming increasingly pathogenic as a result of adaptation on intensively grown cultivars. But the most important threat to plantations is the certainty that new pathogens will continue to be introduced into poplar-growing regions.

Foreign pathogens represent a threat both to natural stands and to plantations of poplars in all parts of the world. If introduced from North America into Europe, Hypoxylon pruinatum (Klotz.) Cke. could cause substantial losses in stands of P. tremula and P. tremula x P. tremuloides. If M. populorum from North America becomes widely distributed in Europe, many plantations of P. x canadensis probably will be badly damaged. Similarly, the bacterial canker of Europe poses a threat to North American species, especially to the balsam poplars. Violet root rot and several other diseases that presently are known only in Japan, could cause substantial losses in other parts of Asia, Europe and North America. Other examples of foreign pathogens that might be serious if introduced into other countries include various rusts (Melampsora spp.) and leaf spotting fungi (Marssonina spp.). Largely undetermined is the possibility of the local existence of dangerous strains of ubiquitous fungi, such as Armillaria mellea (Fr.) Quél., Nectria cinnabarina Fr. and Valsa nivea Fr.

The relative importance of several potentially dangerous diseases can not be predicted because very little is known about them. Poplar mosaic, a disease that has become rather widespread in Europe, deserves careful attention. Virus diseases might be responsible for the reported decline or senescence of certain black poplar cultivars. The cause of a localized bark necrosis of black poplars that is prevalent in Europe and occurs in North America requires further clarification. The disease reduces considerably the quality of the wood of affected trees. In North America, also unknown is the cause of a common, lethal vascular wilt of *P. nigra* var. *italica* and of *P. deltoides*.

These examples of potentially dangerous pathogens and diseases stress the need for even greater international cooperation to determine more precisely the susceptibility of the various poplar species and hybrids to the plant pathogens of the world. Once this is accomplished, poplar breeders may be able to develop high-quality hybrids with resistance to all of the potentially dangerous pathogens. Meanwhile, every possible effort should be made to minimize the introduction of new pathogens into poplar-growing regions.

The objectives of this report are to summarize briefly the major diseases of poplars and to focus attention on diseases or groups of diseases that might cause serious losses if introduced into areas in which they did not previously occur. No attempt is made to list all of the diseases that have been reported on poplars.

In the following lists of pathogenic organisms, hosts are designated by the numbers in parentheses as given in the list of poplar species and hybrids at the beginning of this report.

DISEASES OF SEEDLINGS

Emerging poplar seedlings are highly susceptible to damping-off, presumably caused by *Pythium* spp. This disease is easily controlled, however, by sterilizing seedbeds and by various cultural methods.

Many other diseases occur in nurseries and sometimes cause considerable damage. These include both leaf and stem diseases. None of them, however, is confined to nurseries. For this reason, the diseases that occur in nurseries are dealt with under other headings.

ROOT DISEASES

Root diseases are not considered an important problem on poplars. The following root disease organisms have been reported.

Causal Organism and Type of Damage	Hosts and Distribution
Agrobacterium tumefaciens (Sm. & Town.) Conn Crown gall	(1,3,4,8,14,15) Ubiquitous
Armillaria mellea (Fr.) Quél. Root rot	(2,6,8,9) Ubiquitous
Helicobasidium mompa Tanaka Violet root rot; purple rhizomorphs on roots. This pathogen could cause extensive damage if introduced into other countries from Japan.	(7,13) Japan
Fomes annosus (Fr.) Cke. Root rot	(3,9) Sweden
Rosellinia necatrix (Hartig) Berl. White root rot	(Populus) Japan

STEM DISEASES

Cankers and diebacks. Stem cankers are the most devastating diseases of the poplars, particularly of hybrids. They are controlled primarily by developing or selecting resistant cultivars.

Causal Organism and Type of Damage	Hosts and Distribution
Aplanobacterium populi Ridé Bacterial canker. Exudation of dull cream-colored slime from cracks in wood of young shoots is a diagnostic early symptom. Irregular, erumpent cankers subsequently develop on susceptible cultivars. The cause of the disease was earlier attributed to Pseudomonas syringae Van Hall f. populi Sabet & Dawson but inoculations with pure cultures of this organism failed to induce the disease unless mixed with slime from cankers. Although severely damaging on many poplars, resistant cultivars of P. x canadensis are available. The disease is a major threat to balsam poplars in Asia and North America.	(8,9) France, Netherlands; probably present throughout Europe and possibly present in central Asia.

Bacillus populi Brizi Branch galls	(1,2,7) Italy, France
Cenangium singulare (Rehm.) Davidson & Cash Sooty-bark canker, a disease reported in southwestern United States.	(3) U.S.A.
Ceratocystis fimbriata El. & Halst. A target canker found in the United States primarily on P. tremuloides	(1,3) U.S.A.
Corticium salmonicolor Berk. & Br. Pink disease or shoot blight	(7) Brazil
Cryptodiaporthe populea (Sacc.) Butin. Imperfect stage: Chondroplea (Dothichiza) populea (Sacc.) Kleb. Dothichiza poplar canker. The disease begins as a cortical discoloration that develops into dead patches on smooth-barked stems where the imperfect fruiting stage of the fungus develops. The disease is also known as Dothichiza bark necrosis and dieback.	(1,6,7,8,9,10,11, 12,13,14,15,17,17b) Europe, North America, Argentina
Cryptosporium populi Bon. Stem canker	(6,7, P. sieboldii) Japan
Diaporthe medusaea Nit. Canker and dieback	(6) Japan
Diplodea gongrogena Temme Poplar gall	(1,2,7) Germany, Austria
Fusarium solani (Mart.) App. & Wr. Bark necrosis and canker	(6,8) North America
Hypoxylon pruinatum (Klotz.) Cke. Hypoxylon canker is primarily a disease of P. tremuloides but is also damaging on P. tremula and aspen hybrids. Young cankers on smooth bark appear first as slightly sunken areas with a yellowish-orange discoloration. Bark blisters overlying conidial pillars appear approximately a year after infection. Stromata bearing the perithecia develop a year or two later. H. pruinatum could cause considerable damage if introduced into Europe and Asia.	(1,2,3,4,5,6) North America, Russia

Macrophoma tumefaciens Shear (3,9)
Branch and stem galls — North America

Micrococcus populi Del. (1,2,6,7,8,10, 17a,17b)
Reported commonly associated with cankers on poplars but no causal relationship has been established. — Europe

Nectria cinnabarina Tode ex Fr. (2,6)
Dieback and canker — Ubiquitous

Nectria coccinea Fr. (6,7,8,10,11,12, 13,17b)
Annual stem canker — Europe

Nectria ditissima Tul. (1,2,8,10)
Perennial canker — Ubiquitous

Nectria galligena Bres. (1,3,4,7,8)
Target canker — North America, Europe, Japan

Phomopsis tirreniea Moriondo (1,6,8)
Bark necrosis and dieback of transplanted poplars — Italy

Physalospora populina Maubl. (8)
A canker reported serious on young seedlings in France and Italy — Europe

Poria laevigata (Fr.) Campbell (4)
Trunk canker — U. S.A.

Pseudomonas syringae Van Hall f. *populina* Sabet & Dawson (8,9,10)
Europe
Associated with bacterial canker and previously considered the causal organism. See *Aplanobacterium populi*.

Septoria musiva Pk. (1,7,8,17,17b)
North America, Argentina, France
Perfect stage: *Mycosphaerella populorum* Thompson. *Septoria* canker. The pathogen is responsible for a common leaf spot on North American poplars but causes a serious canker on many hybrids. In the early stages the cankers resemble Dothichiza cankers but later become erumpent. Pycnidia are found readily only on young cankers. Secondary organisms, including various species of *Valsa*, commonly invade the diseased tissues, a factor complicating diagnosis. This disease is potentially dangerous in Europe and Asia.

Valsa nivea Fr. (1,2,5,6,7) Ubiquitous
Dieback and canker.
This fungus is of minor importance on vigorously growing species but is regarded as a potentially dangerous parasite on *P. tremula* x *P. tremuloides* in northern Europe.

Valsa sordida Nits. (1,2,3,5,6,7,8,9,10,14,15,17b) Ubiquitous
Stem canker and dieback.
This pathogen causes a poorly defined canker or bark necrosis primarily on trees weakened by other causes. The pycnidia (*Cytospora chrysosperma* Fr.) can be confused with those of *Chondroplea populea* but are distinguished easily by spore morphology.

Bark necrosis of unknown cause termed: (6,8) Europe, North America
Trunk scab
Braunfleckenrind
Maladie des taches brunes
Batteriosi
The disease is characterized by numerous small trunk lesions from which bacterial slime oozes. Many different organisms have been associated with the disease. In Wisconsin, typical symptoms developed following inoculation with *Fusarium solani*. The cause of the disease in Europe is uncertain.

Heart rots. Heart rots of poplars are of little consequence in plantations because rotations are short. Heartwood stains, however, are common and reduce greatly the value of logs. The stains range in color from dark brown to red or orange. The cause of heartwood stains in poplars is unknown.

The following list of fungi that cause heart rots of poplars is not complete but includes many of the common ones.

Causal Organism and Type of Damage	Hosts and Distribution
Collybia velutipes Curt. White sap rot	(Populus, 3) Ubiquitous
Fomes connatus (Weinm.) Gill. See *Fomes populinus*	
Fomes fomentarius (Fr.) Kickx. White mottled rot	(1,2,3,6,8,10) Ubiquitous

<u>Fomes</u> <u>igniarius</u> (Fr.) Kickx.	(1,2,3,4,6,7,10) Ubiquitous
<u>Fomes</u> <u>pomaceus</u> (Pers.) Lloyd Heart rot	(2) Norway
<u>Fomes</u> <u>populinus</u> (Fr.) Cke. (<u>F. connatus</u> (Weinm.) Gill) White trunk rot	(1,2,6,7,8,10) Europe, South Africa
<u>Ganoderma</u> <u>applanatum</u> S. F. Gray White mottled rot	(1,2,3,6,7,8,10) Ubiquitous
<u>Hydnum</u> <u>caesearum</u> Morgan Trunk decay	(3) U.S.A.
<u>Pholiota</u> <u>destruens</u> (Brond.) Quél. Trunk decay	(7) Denmark
<u>Pholiota</u> <u>squarrosa</u> (Fr.) Quél. Butt rot	(2,3) Europe, North America
<u>Pleurotus</u> <u>ostreatus</u> (Fr.) Quél.	(2,10) Europe, North America
<u>Polyporus</u> <u>adustus</u> (Willd.) Fr. White mottled rot	(Populus) Ubiquitous
<u>Polyporus</u> <u>hispidus</u> Fr. Trunk rot	(Populus, 2) Ubiquitous
<u>Polyporus</u> <u>squamosus</u> Fr. Trunk decay	(2,3,7,8) Ubiquitous
<u>Polyporus</u> <u>sulphureus</u> Fr. Trunk decay	(1,2,8) Ubiquitous
<u>Polyporus</u> <u>zonatus</u> Fr. Trunk decay	(Populus, 1,2,3) Europe, North America
<u>Ustulina</u> <u>vulgaris</u> Tul. Butt decay	(2) U.S.S.R.

Mistletoe

Viscum album L. European mistletoe	(8, 10) France, Germany, Poland

FOLIAGE DISEASES

Leaf rusts. A number of species of Melampsora form uredia and telia on poplar leaves and aecia on other hosts. Poplar clones are selected for resistance to these diseases. Several species, however, could cause extensive damage if introduced into countries in which they do not now occur.

Causal Organism	Hosts and Distribution
Melampsora abietis-canadensis (Farl.) Ludw.	(1, 3, 10) North America
M. abietis-populi Imai	(7) Japan
M. accidioides (DC.) Schroet.	(1) North and South America, India, Europe
M. albertensis Arth.	(3, 8, 9, 10) North America, Argentina
M. allii-populina Kleb.	(7, 8, 9, 10) Europe, Near East, North Africa, Argentina
M. ciliata Barcl.	(P. ciliata) India
M. larici-populina Kleb.	(All black and balsam poplars) Europe, South America, Asia
M. larici-tremulae Kleb.	(1, 2) Europe

M. laricis Hart	(P. sieboldii) Japan, Poland
M. magnusiana Wagn.	(1,2) Europe, Japan
M. medusae Thuem.	(2,7,10,11,13) North America, France, Japan
M. occidentalis Jacks	(1,9,10, P. sargentii) North America
M. pinitorqua Rostr.	(1,2) Europe, Near East, Canada
M. pulcherrima (Bub.) Maire	(1,2,7,16,17b) Italy
M. rostrupii Wagn.	(1,2) Europe
Uredo tholopsora Cumm.	(7, P. tomentosa) China

Other foliage and shoot diseases. Many leaf-spotting fungi have been reported on poplars. Some of them, including Marssonia spp., sometimes cause severe defoliation. Others, particularly Venturia populi and V. tremulae cause dieback of new shoots and sometimes destroy the form of affected trees. In nurseries fungicidal sprays sometimes are used to control foliage diseases.

Causal Organism and Type of Damage	Hosts and Distribution
Alternaria tenuis Nees Leaf spot	(8,15,17) Japan
Apiosporium salicinum (Pers.) Kze. Sooty mold	(Populus sp.) Japan
Ascochyta tremulae Thuem. Leaf spot	(Populus sp.) Austria
Cercospora populina Ell. & Ev. Leaf spot	(1,6,7,13,15,17) U.S.A., Japan

Ciborinia whetzelii Seav. (3, 4)
(*Sclerotinia bifrons* Whetz.) Canada, U.S.A.
Ink spot disease. Causes severe defoliation of *P. tremuloides* in Canada.

Epicoccum nigrum Link *sensu* Schol-Schwarz (8, 17)
Leaf spot Japan

Gloeosporium naevioides Romell & Sacc. (2)
Leaf spot Norway

Gloeosporium tremulae (Lib.) Pass. (2, 5)
(*Titaeosporina tremulae* (Lib.) Luyk) Europe

Glomerella cingulata (Stone) Spauld. & Schrenk
Imperfect stage: *Colletotrichum gloeosporioides* Penz.
Leaf spot and shoot blight (3, various hybrids)
Japan, U.S.A.

Leptosphaeria decaisneana (Crie) Sacc. (15)
Leaf spot Japan

Marssonina spp. Leaf blight of poplars has been attributed to ten different species of *Marssonina*. The number of species on poplars, however, is uncertain. The disease sometimes causes severe defoliation and shoot dieback. The following have been reported on poplars most frequently:

M. brunnea (Ell. & Ev.) Magn. (Black and balsam poplar species and hybrids, including 8)
Japan, Canada

M. castagnei (Desm. & Mont.) Magn. (2, 6, 7, 8)
North America, Europe

M. populi (Lib.) Magn. (1,2,6,7,8,10,11,15)
North America, Europe

M. rhabdospora (Ell. & Ev.) Magn. (Populus)
Europe

Mycosphaerella maculiformis (Fr.) Schroet. (1)
Leaf spot North America, Europe

Mycosphaerella populi (Auers.) Schroet. Leaf spot	(2,7,8) Europe, Argentina, Alaska
Mycosphaerella populicola Thompson Leaf spot	(8,9) North America, Italy
Mycosphaerella populorum Thompson See *Septoria musiva* under stem diseases.	
Pestalotia populi-nigrae Sawada & Ito Leaf and shoot blight, particularly damaging in nurseries.	(2,6,7,15,17) Japan, Italy
Phyllosticta alcides Sacc. Leaf spot	(Populus) Japan
Phyllosticta longisporum Kobay. & Chiba Leaf spot	(1) Japan
Phyllosticta populina Sacc. Leaf spot	(6,7,8) Europe, U.S.A.
Phyllosticta populi-nigrae Allesch. Leaf spot	(10) British Isles
Phyllosticta populorum Sacc. & Roum. Ring spot on leaves	Attacks most, if not all, poplar species and hybrids grown in Japan.
Phyllosticta prominens Oud. Leaf spot	(10) Netherlands
Pseudopeziza populi-nigrae Kleb. Leaf spot and twig canker	(1,7,10,17b) North America, Europe
Septotinia podophyllina Ell. & Ev. Leaf and shoot blight	(8) Netherlands
Septotinia populiperda Waterman & Cash Imperfect stage: *Septotis populiperda* Waterman & Cash (*Septogloeum populiperdum* Moesz. & Smarods) Septotinia leaf blotch occasionally causes severe damage in nurseries.	(2,5,6,7,8,13,14,17) Europe, North America, Japan

Sphaceloma populi (Sacc.) Jenkins (Populus sp., 7)
Spot anthracnose or scab — Japan, Argentina

Sphaerulinia populi Kobay. & Chiba (8)
Leaf spot — Japan

Taphrina aurea (Pers.) Fr. (2,6,7,8,10,11, 17,17a,17b)
Leaf blister, a conspicuous but unimportant disease — North America, Europe, India, China, Japan

Taphrina johansonii Sadeb. (2,8)
Catkin hypertrophy — Europe, Japan

Taphrina rhizophora Johans. (1)
Catkin hypertrophy — Europe

Uncinula adunca (Fr.) Lev. (1,2,7,8,12)
(U. salicis (DC.) Wt.)
Powdery mildew — Ubiquitous

Venturia populina (Vuill.) Fabr. (7,10,14,17b)
Imperfect stage: Pollaccia elegans Serv.
Spring defoliation of black and balsam poplars. — Europe, North America

Venturia tremulae Aderh. (1,2,3,4,5)
Imperfect stage: Pollaccia radiosa Lib. (Bald.) — North America, Europe
Spring defoliation of aspens. The disease is characterized by withered, blackened shoots. In North America it is particularly severe on P. alba x P. grandidentata.

SYSTEMIC DISEASES

Viruses

Mosaic virus (6,10)
Europe

Vascular wilts. In the United States, P. nigra var. italica is susceptible to a vascular disease of unknown cause. The symptoms of the disease include a conspicuous wilting of the foliage and a reddish-brown discoloration of the wood. The disease is lethal. Similar symptoms with the same end result also are common on P. deltoides.

The only known vascular pathogen of poplars in the United States is *Corynebacterium humiferum* Seliskar, a bacterium that causes wet wood in *P. nigra* var. *italica* and in *P. tremuloides*. It is common in trees of all sizes, including many that are apparently healthy. In advanced stages it causes a slow decline with scattered branches dead or dying. Discoloration of entire cross section of stem precedes death of trees. No control is known.

DISEASES OF QUERCUS IN THE UNITED STATES

by

James E. Kuntz[1]

Importance of the Genus

In the United States, the oaks are represented by more than 50 native species and a greater number of recognized hybrids. The "Check List"[2] states that the genus Quercus of the family Fagaceae is the largest genus of native trees in number of species with the exception of Crataegus. American oaks fall into two main groups: the white oaks (Leucobalanus) and the red or black oaks (Erythrobalanus), each with distinguishing characteristics and of about equal numbers of species. They range widely and flourish on many different soils and sites and under a wide variety of environmental conditions - except in very cold regions.[3] Although oaks occur on the Pacific Coast and in the Southwest, the important forest species grow in the eastern, central, and some southern states. The oak-hickory type includes nearly one-fourth of the total commercial forest land area of the United States.[4] The different species, depending somewhat on growing conditions, vary greatly in size from small shrubs to magnificent forest trees. The majority are deciduous, but a few western and southern species are evergreen. Although slow growing, many are hardy, very long-lived, and attain heights of over 100 feet with correspondingly massive trunks.

The importance of oaks in North America as well as in temperate parts of Europe, Asia, and North Africa can scarcely be overemphasized. Oaks constitute the leading hardwood timber species

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1 Department of Plant Pathology, University of Wisconsin, Madison, Wisconsin, U.S.A. For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964.

2 Little, E. L., Jr. 1953. Check list of native and naturalized trees of the United States (including Alaska). U.S. Dept. Agr., Forest Service Handbook 41. 472 p.

3 U.S. Forest Service. 1948. Woody-plant seed manual. U.S. Dept. Agr. Misc. Publ. 654. 416 p.

4 U.S. Forest Service. 1958. Timber resources for America's future. U.S. Dept. Agr. Forest Resource Rept. 14. 713 p.

in the United States (see footnote 4). They contribute three-eighths of eastern hardwood timber growth and comprise about an equal portion of the total hardwood sawtimber volume. More than half of the species are of economic importance for timber and other purposes.

Oaks have many uses.[5] Oak wood is characterized by great strength, sturdiness, and hardness; natural durability; and beauty when finished. It provides lumber for general construction, fuel (including charcoal), tight cooperage (white oaks), railroad ties and mine timbers, poles and posts, veneer, furniture and other finished products, timbers for shipbuilding, and lumber for railroad-car construction, vehicle parts, boxes and crates, implements, and other wood products.[6] The bark of some species provide tannin and other products. Oak stands protect vast watersheds and provide food and shelter for many forms of wildlife. Acorns furnish quantities of "mast" for wild and domesticated animals.

In addition to their direct economic importance, oaks have great aesthetic values as shade and ornamental trees on lawns, in parks, and along streets in nearly all parts of the United States. The foliage in the spring is light green, soft, delicate, and feathery; in the summer, a deep green, bright and shiny; and in the autumn, brilliantly colored.

Present and Potential Disease Impact

Because of the large number of *Quercus* species and hybrids growing so widely throughout the United States, and because of the considerable variation each exhibits, generalizations about oaks as a group are difficult. Fortunately, the silvical characteristics of a number of oak species have been summarized.[7]

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5 Brown, H. P., A. J. Panshin, and C. C. Forsaith. 1949. Textbook of wood technology. Vol. 1. Structure, identification, defects, and uses of commercial woods of the United States. McGraw-Hill Book Co., New York. 652 p.

6 U.S. Dept. Agr. 1949. Trees. Yearbook of Agriculture, 1949. 944 p.

7 See the series of papers on silvical characteristics of important forest trees of the United States published by various U.S. Department of Agriculture Forest Service Experiment Stations.

These many factors, heritable and environmental, influence disease incidence and severity, the manner and rate of pathogen dissemination, and possibilities for disease prevention through adjustments in management practices. Thus, responsibility lies with the forest manager for the application of practical control measures already developed. For the forest pathologist, tree physiologist, and biochemist, the different oaks provide unique plant material for fundamental studies of disease mechanisms, host-parasite interactions, and environmental effects. For the forest pathologist and tree breeder, this natural diversity among oaks already growing throughout the world, as well as their proclivity to hybridize, offers a wealth of genetic material for field and nursery selection, further hybridization, and progeny testing for disease resistance. Unfortunately, practical methods of vegetative propagation have not yet been developed for most species.

Most oaks grow in association with many other tree species and are important components of several forest cover types.[8] As climax or subclimax associations, these stands contain trees of uneven age. This natural dispersion no doubt limits disease development and deters epiphytotics. Under certain conditions, even-aged, pure stands occur locally.

Natural regeneration of oaks with relatively low shade tolerance (intermediate to intolerant) is encouraged by some form of partial cutting. The shelterwood system or the small-group or individual selection system provides openings large enough for light and heat to promote seed germination and early growth. Unfortunately, insects, birds, rodents, and other animals destroy a large portion of the acorns and thus limit or prevent natural seedling regeneration. Moreover, emerging seedlings are subject to continued attack by these agents as well as to injury from fungi, fire, flooding, drought, and frost. Heavy competition from annual weeds, vines, briars, and brush also reduce survival and retard early growth. As with many hardwoods in the United States, artificial regeneration of oak by direct seeding or by transplanting nursery stock has not been adequately explored. Relatively little use of oaks is made in forest plantings, though a few species are used in shelterbelt planting, and for shade and ornamental purposes. Vegetative propagation is usually difficult whether by layering, rooting of cuttings, budding, or grafting.

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8 Society of American Foresters. 1954. Forest cover types of North America (exclusive of Mexico). Washington, D. C. 67 p.

Existing second-growth stands of many oak species are of seedling- or stump-sprout origin. Stumps of small trees (pole size or smaller) sprout vigorously after cutting or after top-killing by fire. In general, pole sprouts of low origin or seedling sprouts form satisfactory trees. But sprouts originating high on the stump or from large stumps are likely to have a high incidence of butt rot entering from the old stump. Careful application of timber stand improvement methods can minimize the decay hazard in sprout oak stands.[9]

In the past, fire has been the chief cause of defect in oaks (see footnote 7). Fire not only kills seedlings and saplings, severely damages older trees, and predisposes survivors to insect attack, but also causes fire scars which provide ideal entry points for decay fungi. Moreover, in farmers' woodlots, grazing cattle not only destroy young reproduction and forest litter, compact the soil, and incite erosion, but also variously injure tree trunks and buttress roots so that heart rot follows. In all cases, considerable butt and trunk rot can be avoided by protecting forest stands from fire and grazing.

Oaks are attacked by many decay fungi as well as by a multitude of pathogens that incite trunk and branch cankers; twig and branch dieback; leaf spots, mildews, and foliage blights; and vascular wilt diseases. Noninfectious diseases incited by abiotic agents seldom are mentioned except as adverse environmental conditions predispose weakened oaks to facultative parasites or to secondary organisms. Little is known about viruses or nematodes as possible incitants of oak diseases. Probably because few oaks are planted, few seedling, nursery, or plantation diseases are recorded. Most recognized diseases affect older trees. The great majority are endemic. No doubt heart rots presently account for the greatest economic loss, although such loss can be reduced by proper management of hardwood stands. Stem cankers, though occurring only on scattered trees, may kill young trees, reduce stocking and productivity of stands, and result in cull deduction in the valuable butt log. Foliage diseases appear to be of little consequence in forest stands, but leaf spots and foliage blights of valuable shade and ornamental trees cause great concern. Moreover, epiphytotics in local areas frequently cause lasting damage. Serious, sporadic outbreaks occur when environmental conditions particularly favorable to the pathogen and to disease development permit attack of highly susceptible oak species or varieties.

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9 Roth, E. R. 1956. Decay following thinning of sprout oak clumps. J. Forestry 54:26-30.

Inadvertent transfer of pathogens to new geographic regions with climatic conditions favoring disease development or with highly susceptible host populations, as in the past, could lead to disastrous disease epidemics. Needless to say, continued research must provide basic information regarding life cycles of disease incitants, disease cycles, environmental relationships, and means of dissemination, all of which are prerequisite to formulate effective control measures.

The greatest potential threat to oaks both in the United States and elsewhere is the oak wilt disease. Though thousands of oaks have been killed, particularly in the Upper Mississippi River Valley, the disease has not become epidemic. In eastern United States the disease still is limited to small, scattered infection centers. Fortunately, intensive research has provided several control measures effective in reducing local (root-graft) and long distance (overland) spread.

The following summary is assembled and adapted mainly from the "Index of Plant Diseases in the United States", U.S. Department of Agriculture Handbook 165. Thus, the following groups and species of oaks are considered:

I. White Oak Group, Eastern and Central United States

1. _Quercus alba_ L., white oak
2. _Q. bicolor_ Willd., swamp white oak
3. _Q. lyrata_ Walt., overcup oak
4. _Q. macrocarpa_ Michx., bur oak
5. _Q. stellata_ Waugh., post oak

Large forest trees, except (5); important commercially; also cultivated for shade and ornament; useful to wildlife.

II. White Oak Group, Western United States

6. _Quercus gambelii_ Nutt. (including _Q. leptophylla_ Rydb. and _Q. utahensis_ (DC.) Rydb.), Rocky Mountain white oak
7. _Q. garryana_ Hook., Oregon white oak
8. _Q. lobata_ Née, valley white oak

Large trees furnishing commercially useful wood and also planted for shade or ornament, except (6) which is a small tree or shrub; useful to wildlife.

III. Chestnut Oak Group, Eastern United States

9. _Quercus montana_ Willd., chestnut oak
10. _Q. prinus_ L., swamp chestnut oak
11. _Q. muhlenbergii_ Engelm., chinquapin oak
12. _Q. prinoides_ Willd., dwarf chinquapin oak

Large (9,10) and small (11,12) trees; useful to wildlife

IV. Miscellaneous White and Chestnut Oaks, Western United States

13. Quercus arizonica Sarg., Arizona white oak
14. Q. douglasii Hook. & Arn., California blue oak
15. Q. dumosa Nutt., California scrub oak
16. Q. engelmanii Greene, evergreen white oak
17. Q. oblongifolia Torr., Mexican blue oak
18. Q. undulata Torr., Rocky Mountain shin oak

Shrubs or small trees; somewhat to fully evergreen; useful in erosion control and for fuel; some furnish browse for livestock and are important food plants of wildlife.

V. Red, Black, and Pin Oak Group

19. Quercus borealis Michx. f., including the more robust form sometimes designated var. maxima (Marsh.) Ashe, northern red oak
20. Q. coccinea Muench., scarlet oak
21. Q. ellipsoidalis E. G. Hill, northern pin oak
22. Q. falcata Michx., southern red oak (Spanish oak)
23. Q. palustris Muench., pin oak
24. Q. velutina Lam., black oak

Large forest trees furnishing commercially important wood; also grown for shade, especially (19,20,23); (23) frequently used as a street tree; useful to wildlife.

VI. Water and Willow Oaks

25. Quercus imbricaria Michx., shingle oak
26. Q. laurifolia Michx., laurel oak
27. Q. marilandica Muench., blackjack oak
28. Q. nigra L., water oak
29. Q. phellos L., willow oak

Mostly large trees furnishing wood of some commercial importance; also grown under cultivation, especially (28) and (29), for shade and ornament; useful to wildlife.

VII. Live Oak Group

30. Quercus agrifolia Née, California live oak
31. Q. chrysolepis Liebm., canyon live oak
32. Q. virginiana Mill., southern live oak (including var. geminata (Small) Sarg.)
33. Q. wislizenii A.DC., interior live oak

Large evergreen trees, becoming shrubby in exposed sites and forming extensive ground cover; widely used for shade and as specimen trees in the South and California; useful to wildlife.

VIII. Cultivated Oaks, Introduced Species

34. *Quercus cerris* L., turkey oak. Native of southern Europe and western Asia; cultivated.
35. *Q. robur* L., English oak. Native of western Europe to Asia and northern Africa; cultivated.
36. *Q. suber* L., cork oak. Native of southern Europe and northern Africa, source of cork; cultivated to a limited extent in California.

SEEDLING DISEASES*

Few specific seedling diseases of oak are recorded. In fact, relatively little is known of diseases of hardwood seedlings since they have not been grown extensively in the United States.[10] Seedling regeneration of oaks occurs under natural conditions in the forest. Both biotic and abiotic agents destroy many acorns and emerging seedlings. Opening of stands, maintenance of a light leaf litter, and prevention of fire, grazing, and of excessive weed and brush competition will encourage seedling reproduction. Under semi-controlled conditions in the nursery, good cultural practice will avoid damage from adverse edaphic and climatic factors while the use of healthy seed, seed treatment, soil fumigation and timely application of effective fungicides will reduce damage and losses from pathogenic agents. (See also foliage and certain root diseases.)

Causal Agent and Disease	Species Affected and Occurrence
Adverse environmental conditions including fire, late spring frosts, flooding, drought, herbicides, and other toxic agents (misuse of), various forms of winter kill, etc. Noninfectious diseases	Occasional.

* E, N, S, W, etc., indicate general geographic regions in the United States where the disease has been reported.

The terms "white, black, or red" refer to the two major groups of oaks.

Numbers in parentheses refer to *Quercus* species numbered above.

10 Boyce, J. S. 1961. Forest pathology. 3rd Ed. McGraw-Hill, New York. 572 p.

Causal Agent and Disease (cont.)	Species Affected and Occurrence
Agrobacterium tumefaciens (E. F. Smith & Town.) Conn Crown gall	Rare.
Generally, species of *Pythium*, *Phytophthora*, *Fusarium*, and *Rhizoctonia*. Damping-off and root rots	Attack young seedlings of both conifers and hardwoods.
Cuscuta spp. Dodder	This parasitic phanerogam attacks many plants, including young hardwood seedlings. In nurseries, occasionally both white and black oak seedlings are attacked.
Phoma glandicola (Desm.) Lév. (also known as *Phomopsis glandicola* (Lév.) Grove) Dry rot of acorns	(1,10,24,32) in E and S.
Phomopsis quercinum (Sacc.) Hoehn. Acorn rot (also reported as a twig canker)	(10)
Thelephora terrestris Ehr. ex Fr. Smothering of seedlings	(1,etc.). Fruiting bodies of fungus smother or strangle seedlings (non-parasitic).

FOLIAGE DISEASES

Many species of fungi incite spots, blotches, and blights of leaves on oaks. Most of the diseases are endemic, developing at a low level over wide areas each year. Occasionally, however, certain foliage diseases become unusually severe in local areas if environmental conditions are especially favorable and if host tissues are susceptible during the time of spore discharge. Few of the diseases or the causal organisms have been studied in detail so their effects on tree vigor and growth are not really known. Still, most foliage diseases appear to cause little damage to natural forest stands and are of most concern on valuable shade and ornamental trees. In the latter situation, sanitation (the gathering and burning of infected leaves and twigs to reduce overwinter inoculum) and one or more applications of protective fungicidal sprays provide satisfactory control. Otherwise, repeated heavy defoliations may reduce tree vigor so as to predispose the weakened tree to more

destructive pathogens. Fortunately, with many foliage diseases, both incidence and severity of the disease are limited by environmental conditions, wide dispersion of the susceptible host, and a relatively short period of host susceptibility. In solid, even-aged plantings, however, foliage diseases may be aggravated.

Leaf rusts, though of little consequence to the oaks themselves, are of importance in that Quercus species serve as the alternate hosts for certain heteroecious rusts extremely destructive to pines.

Local spread generally is by windblown spores. Long distance spread, however, could result from transport of diseased transplants, especially where twig tissue also is infected.

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Acantharia echinata (Ell. & Ev.) Th. & Syd. Black leaf spot	(30,31,33) Live oaks in W.
Actinopelte dryina (Sacc.) Hoehn. Leaf spot (small, brown)	Many oak species in both E & W.
Cercospora macrochaeta Ell. & Ev. Leaf spot	(31) in California.
Cercospora polytricha Cke. Leaf spot	(32) in SE.
Cronartium cerebrum Hedgc. & Long. (also called C. quercuum (Berk.) Miyabe by some authors) Leaf rust (II,III)	A heteroecious rust with uredia and telia on the undersurface of leaves of oak and chestnut and aecia on stems and branches of two- and three-needle pines, mainly in eastern North America; a serious disease of pine in nurseries and young plantations, but of little consequence on oak. A number of white and especially black oaks are attacked (1,2,4-6,9,10,12,15,19-25,27-30,32). Intercontinental spread is possible by shipment of infected pine seedlings.
Cronartium conigenum Hedgc. & Hunt Leaf rust (II,III)	A heteroecious rust with uredia and telia on leaves of Q. emoryi Torr., Q. hypoleucoides Camus and Q. arizonica (13) in Arizona; pycnia and telia on cones of Pinus leiophylla var. chihuahuana (Engelm.) Shaw.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks

Cronartium fusiforme Hedgc. & Hunt
Leaf rust (II,III)

A heteroecious rust with uredia and telia on the undersurface of leaves of various oaks, especially black oaks; and causing perennial stem and branch galls on southern hard pines in southeastern United States. A serious disease of young pine in nurseries and plantations, but of little significance on oak. Susceptible oaks include (1,5,19,20,22-29, 32,34-35). Species of Castanea, Castanopsis, and Lithocarpus have proved susceptible by artificial inoculations. Intercontinental spread is possible by shipment of infected pine seedlings.

Cronartium strobilinum Hedgc. & Hahn
Leaf rust (II,III)

A heteroecious rust with uredia and telia on the undersurface of leaves of several oaks and pycnia and aecia on cones of Pinus elliottii Engelm. and P. palustris Mill. in central and southeastern United States. Susceptible oak species include (1,4,5,26,28,32).

Cylindrosporium kelloggii Ell. & Ev.
Leaf spot

Certain oaks in California.

Cylindrosporium microspilum Sacc. & Wint.
Leaf spot

(1,5,23) in Illinois and Missouri.

Dothidella janus (Berk. & Curt.) Hoehn
Leaf spot

(32) in Florida and Texas.

Dothiorella phomiformis (Sacc.) Petr. & Syd.
Leaf spot

Especially on white and chestnut oaks in E (1,2,4,5,9,10,11,19).

Elsinoë quercus-falcatae (Miller)
Leaf spot

On southern red oaks.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Erysiphe trina Harkn. Powdery mildew, witches' broom	(30) in California.

Gloeosporium spp.
Several species reported to incite leaf spots, anthracnose, and even twig blight on Quercus species mainly in eastern and central United States.

G. bicolor McAlp	(2)
G. bicolor var. velutinae Overh. & Dearn.	(19,24)
G. canadense Ell. & Ev.	(1,2,4,9,10,23,etc.) in E.
G. divergens Pk.	(1)
G. quernum Harkn.	(30)
G. nervisequum (Fckl.) Sacc.	(1)
G. septorioides Sacc.	(24)

Gloeosporium quercinum West (conidial stage of Gnomonia quercina Kleb. and probably includes certain of the above species) Leaf spot and anthracnose, oak anthracnose, leaf scorch — A leaf and twig blight of many Quercus species, especially of Q. alba (1), Q. macrocarpa (4) and other white oaks in eastern and northern United States; locally, during moist spring weather, can incite a severe and unsightly scorched appearance of the lower foliage and even premature defoliation, but infected trees commonly regain their normal appearance by midsummer; also may cause twig canker and dieback. For valuable shade and ornamental trees, control measures include repeated application of fungicidal sprays and destruction of dead leaves and cankered twigs.

Gnomonia quercina Kleb. (see Gloeosporium quercinum West, the conidial stage; on Quercus species, differentiated from G. veneta (Sacc. & Speg.) Kleb. as commonly applied to anthracnose of Platanus.) Leaf spot, anthracnose, scorch — Mainly in eastern United States; reported on (1,2,4,5,7,9,10,etc.).

Laestadia auripunctum Harkn. Leaf spot	(31,33) in California.
Leptosphaeria dryophila (Cke. Harkn.) Sacc. Leaf spot	(24,30) in North Carolina and California.
Leptostroma querci Tehon. Leaf spot	(25) in Illinois.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Leptothyrium californicum Bub. Leaf spot	(30,etc.)
Marssonina martini (Sacc. & Ell.) Magn. Brown bordered leaf spot, eyespot	General distribution with oaks in E and C. (1-5,9-11, 24,35)
Marssonina quercina (Wint.) Lentz Leaf spot	In E and C, mostly on black oaks (19-21,24,25,28-29).
Microsphaeria alni DC. ex Wint. Powdery mildew	Common on coppice and nursery plants in E, but not too important on native oaks since some resistance expressed (1-12, 19-24,30,32,35).
Microsphaeria alni var. calocladophora (Atk.) Salm. Powdery mildew	(1,6,8,26,28) in SE and W.
Microsphaeria alni var. extensa (Cke. & Pk.) Salm. Powdery mildew	(1,12,19,21,23-25,28,35) in E, C, and S.
Monochaetia desmazieri Sacc. Large leaf spot; leaf blotch	A damaging leaf spot in SE, especially on red oaks (1,5,9, 19-24,27,28,30,32,etc.).
Monochaetia taphrinicola (Ell. & Ev.) Sacc. Leaf spot; leaf blotch	(1,19,20,23,28,32) in E and S.
Morenoella quercina (Ell. & Martin) Th. Leaf spot, black mildew, black leaf spot, purple blotch	(5,10,19-24,26,27-29,32) in S and SE.
Mycosphaerella spp. Several species on fading or fallen leaves; occasionally as leaf spots.	(9) in Kansas.
Ovularia sp.	(9) in Kansas.
Passalora melioloides Tracy & Earle Black leaf spot	(26,32,etc.) in SE.
Pestalotia spp. Leaf spot of fading or fallen leaves, probably secondary	Black oaks in E.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Phleospora hanseni Bub. Leaf spot	Live oak species in W.
Phyllactinia corylea Pers. ex Karst. Powdery mildew	Widely distributed on (1,4,5, 19,20,23,24,27-30).

Phyllosticta spp.
Several species occur widely on fading or fallen leaves and may cause leaf spots.

P. agrifolia Ell. & Ev.	(30,31)
P. livida Ell. & Ev.	(1,4,28,32,etc.)
P. ludoviciana Ell. & Martin	(28)
P. neuroterigallicola Tehon	(25)
P. phomiformis Sacc.	(1,4,10)
P. quercea Davis	(2)
P. quercus Sacc. & Speg.	(4)
P. quercus-prini	(9)
P. tumoricola	(1)
P. virens Ell. & Langl.	(32)
P. wislizenii Ell. & Ev.	(33)

Septogloeum defolians Harkn. Leaf spot	*Q. kelloggii* in California.
Septogloeum querceum Davis Leaf spot	(2) in Wisconsin.

Septoria spp.
Several species incite leaf spots of oak; others are found only on fading leaves; widely distributed.

S. dryina Cke.	(5,22)
S. neglecta Earle	(29)
S. ocellata (Lév.) Sacc.	(7)
S. querceti Thuem.	(19,24)
S. quercicola (Desm.) Sacc.	(19,30,32)
S. quercicola var. *cinerea* Ell. & Ev.	
S. quercus Thuem.	(1)
S. serpentaria Ell. & Martin	(26)

Sphaerotheca lanestris Harkn. Brown mildew, powdery — Common and troublesome on leaves and shoots of both white and black oaks in S and W (1,2,4,5, 10,16,19,22,30,35,36,etc.); causes a witches' broom on coast live oak in California.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Taphrina caerulescens (Mont. & Desm.) Tul. Leaf blister, leaf curl, blister blight	Common and widely distributed on many species of both white and black oaks; most serious on red or black oaks and most damaging in the S; on shade and ornamental trees controlled by fungicidal sprays (1,4-7,9,14,18-30,32,etc.).
Trabutia erythrospora (Berk. & Curt.) Th. & Syd. Black spot, sooty blotch	(13,17,30-32) in S and W.
Trabutia quercina (Fr. & K. Rudolphi) Sacc. & Roum. Tar spot	(26,28,29,32,etc.) in S.

BRANCH CANKERS AND DIEBACKS

Many different fungi incite, or at least are associated with, twig blights and diebacks of oaks. Frequently it is difficult to know whether these agents are primary pathogens or secondary invaders. Few detailed studies have been made, but circumstantial evidence suggests that infection frequently follows on trees weakened by adverse environment or other predisposing factors. In the forest, soil compaction, erosion, fluctuations of the water table, ground fires, flooding, grazing, sudden opening of the stand, and like disturbances favor disease development. Activities in urban areas complicate the situation even more. At times, dieback becomes quite serious in a given locality and challenges the ingenuity of the pathologist to diagnose the often complex situation.

Every effort should be made to avoid or to correct adverse circumstances which reduce tree vigor and predispose trees to fungus attack. Badly deteriorated trees should be removed in timber stand improvement operations. Valuable shade and ornamental trees should be fertilized, watered, and perhaps sprayed to control insects and foliage diseases. Diseased and dead twigs and branches should be pruned off and destroyed.

The movement of infected planting stock could transport the causal fungi over long distances, but the possibility for disease development would depend largely on factors determining tree vigor and growth. The danger still exists, however, that a fungus like Endothia parasitica, of little or no consequence on oaks, could develop into epidemic proportions in a new situation of highly susceptible hosts, extremely favorable environment, and an efficient means of spread. It has happened!

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Botryodiplodia ravenelii Sacc. Twig blight	Q. coccinea (20) in Ohio.
Coniothyrium truncisedum Vest. Twig dieback?	(1,2,4,19,23,24) in Illinois.
Corticium spp. Numerous species reported on dead twigs and branches.	
Coryneum spp. Several species reported on dead branches, but their significance on living oaks is uncertain.	
Cytospora spp. Certain species occasionally associated with twig canker and dieback.	
Cytospora chrysosperma Pers. ex Fr. Twig canker and dieback	Especially black oaks in E.
Diatrype spp. Branch cankers	On dead branches, but sometimes associated with cankers of both white and black oaks.
Dichaena quercina Pers. ex Fr. Branch canker?	On twigs and branches (20,30,etc.)
Dichaena strumosa Fr. Twig and branch canker	(20,24,28) in E.
Diplodia longispora Cke. & Ell. (Some authors use Sphaeropsis quercina Cke. & Ell. as a synonym and as the imperfect stage of Physalospora glandicola (Schw.) Stevens) Twig blight and branch dieback	Occasionally damaging in local areas, especially on red and chestnut oaks in E (1,4,9,10,19, 20,32). Twigs and small branches are killed.
Dothiorella quercina (Cke. & Ell.)Sacc. Twig and branch canker, Dothiorella canker	Attacks twigs, branches and occasionally the trunk of both white and black oaks (1,4,7,10,19,23, 30,etc.); may cause severe damage to shade and ornamental oaks in E and C.
Endothia parasitica (Murr.) P. J. & H. W. Anderson Twig canker	Some damage to Q. stellata (5) in E and C; also a saprophyte on various oaks.
Fusicoccum ellisianum Sacc. & Syd. Twig canker	(19,24,etc.) in E.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Nectria spp. Various species associated with branch cankers on oak, but probably in a secondary role.	
Nectria cinnabarina Tode. ex Fr. Twig canker and dieback	The fungus is widespread as a hardwood saprophyte, but may be associated with branch dieback of oaks (19,20,22,28) in E and SE.
Nectria coccinea (Pers. ex Fr.) Fr.	(7)
Nectria ditissima Tul.	(1,20,24,etc.)
Phoma aposphaerioides Briard & Har. Twig canker	(19) in Illinois.
Phoma quercina (Pk.) Sacc. Twig canker	(1,4,5,19) in E.
Physalospora spp. Several species on fallen leaves, dead bark, and even acorns, but may cause twig canker and dieback.	
Physalospora glandicola (Schw.) N. E. Stevens (see Sphaeropsis quercina Cke. & Ell., the imperfect stage) Twig canker and dieback	Particularly red and chestnut oaks suffer from this disease in E; can be damaging (1,4,9-11, 19,20,23,24).
Pseudovalsa longipes (Tul.) Sacc. Twig canker and dieback	(1,9,19-25,30,32) in E.
Pyrenochaeta minuta Carter Twig canker	(1,23) in Illinois
Septobasidium spp. Several species reported to cause a "brown felt" on scale-infested branches.	
S. alni Torrena	(28,29) in SE.
S. burtii Lloyd	(23) in E.
S. castaneum Burt	(26,28,29) in SE.
S. cokeri Couch	(22,24-26, 29,etc.) in E and SE.
S. curtisii (Berk. & Desm.) Boed. & Steinm.	(28,29)

Causal Agent and Disease (cont.)	Quercus Species Affected,	U.S. Occurrence, Remarks
Septobasidium spp. (cont.)		
S. pseudopedicellatum Burt		(20,26,28) in SE.
S. sinuosum Couch		(7,26,28) in SE.
S. tenue Couch		(26) in SE.

Sphaeropsis quercina Cke. & Ell.
(see Physalospora glandicola (Schw.) Stevens, the perfect stage)
Twig canker and dieback

STEM DISEASES

A. Stem Cankers

Stem cankers of oak cause cull and some loss of merchantable volume, breakage of branches and trunk, and perhaps even more important, a waste of growing space. The butt log, where most cankers occur, is rendered unmerchantable. Although relatively few older trees in a stand may be diseased, incipient cankers on young trees are easily overlooked or disregarded, and many young trees are killed unnoticed.

Although most cankers develop slowly, rarely do infected trees recover. The causal fungi overwinter in the perennial cankers and provide abundant inoculum under favorable environmental conditions. Many appear to be wound invaders and, in some cases, increased infection appears to follow adverse environmental conditions which weaken trees. Actually, critical investigations of many of these diseases are needed to clarify the biology of the respective pathogens, environmental influences, means of spread, avenues of infection, host-parasite interactions, and possible disease resistance. Such knowledge will enable the formulation of improved control measures.

In forest stands, infected trees should be recognized early and removed in weeding and thinning cuts. Canker-free crop trees should be selected. In harvest cuts, cankered trees also should be removed - and utilized where possible. Wounding of trees should be avoided and all effort made to encourage good growth and vigor. Whether oak plantings will suffer more than natural mixed, uneven-aged stands will depend in some degree on site selection, local environment, and other conditioning factors.

Badly infected shade trees also should be destroyed. Otherwise cankered branches should be pruned off during the summer when they can be easily recognized. Fertilization, watering, and other measures to improve tree vigor may help reduce disease incidence.

The chances of intercontinental transport of badly infected logs is rather small, since stems with old cankers would be discriminated against in the forest or mill, discarded, or used for fuel. Incipient cankers usually occur on young trees or branches and might pass unnoticed on transplant stock. Also, certain causal fungi, like Nectria, could be carried along on the bark beyond definitely cankered areas of logs and rough lumber.

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Hypoxylon spp. Many species reported on dead bark and dead wood; sometimes associated with cankers.	
H. annulatum (Schw.) Mont.	On several species of both white and black oaks.
H. atropunctatum (Schw. ex Fr.) Cke.	On several species of both white and black oaks.
H. atropunctum (Schw. ex Fr.) Cke.	(1,5)
H. cohaerens (Pers. ex Fr.) Fr.	
H. deustum (Hoffm. ex Fr.) Grev.	
H. fragiforme (Pers. ex Fr.) Kickx.	On several species of both white and black oaks.
H. howieanum Pk.	On several species of both white and black oaks.
H. marginatum (Schw.) Berk.	On several species of both white and black oaks.
H. mediterraneum (deN.) J. H. Miller	(7)
H. morsei (Berk. & Curt.)	On several species of both white and black oaks.
H. multiforme (Fr.) Fr.	(1)
H. occidentale Ell. & Ev.	On live oaks.
H. punctulatum (Berk. & Rav.) Cke.	On several species of both white and black oaks.
H. rubiginosum Pers. ex Fr.	On black oaks.
H. serpens Pers. ex Fr.	On black oaks.
H. truncatum (Schw. ex Fr.) J. H. Miller	On black oaks.
Nectria galligena Bres. Nectria canker, trunk canker, trunk and branch canker.	Widespread in North America (NE, NC, NW) on many native hardwoods; most serious and prevalent on oaks (1,2,7,etc.) in E; generally, in any stand, few trees are infected or killed.

Causal Agent and Disease (Cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Phaeobulgaria inquinans (Pers. ex Fr.) Nannf. Basal canker?	On bark and dead branches and trunks, but also reported to cause a basal canker of white and especially black oaks of low vigor.
Physalospora glandicola (Schw.) N. E. Stevens (Sphaeropsis quercina Cke. & Ell., the conidial stage.) (see under "Branch Cankers and Diebacks")	Both white and black oaks (1,4,5,9-11, 19-24,27,etc.) in E and C are cankered and sometimes killed. Initial infection usually occurs through twigs and branches, from which the fungus invades the trunk.
Phytophthora cactorum (Leb. & Cohn) Schroet. Bleeding canker	Usually a basal canker from which oozes a reddish-brown liquid; important on several shade and ornamental trees including an occasional oak.
Polyporus hispidus Bull. ex Fr. Hispidus canker	Although chiefly associated with heart rot, the fungus can also attack sapwood and cause elongated trunk cankers. (See under heart rot).
Poria laevigata (Fr.) Karst. Stem canker	On red oaks in S.
Strumella coryneoidea Sacc. & Wint. Strumella canker, oak canker, trunk and branch canker	Widely distributed in E attacking mainly oaks, especially black oaks (1,4,7, 9,19,20,23,24,28,etc.), but occasionally other hardwoods. In any stand, relatively few trees are infected. Young trees may be girdled and killed.

B. Vascular Wilts

Oak wilt is potentially the most destructive disease of both red and white oaks. So far, it has been reported only in eastern United States, is most serious in Upper Mississippi River Valley, but has not become epidemic. Research already has clarified many aspects of the disease and has provided several control measures effective in reducing or preventing tree-to-tree spread in local areas as well as overland spread for longer distances. Intercontinental spread could occur through shipment of logs or rough lumber from infected trees. Fortunately, most of the outer infected sapwood is slabbed off in the sawing of lumber. Otherwise, kiln drying to a moisture content of 20 per cent or less will kill the fungus in infected lumber. Recent research has demonstrated that fumigation with methyl bromide will eliminate the fungus in infected logs.

Causal Agent and Disease	*Quercus* Species Affected, U.S. Occurrence, Remarks
Ceratocystis fagacearum (Bretz) Hunt Oak wilt	All oak species, tested by natural or artificial inoculations, have proved susceptible,

although white oaks generally are more resistant to the disease. In the Fagaceae, the genera *Castanea*, *Castanopsis*, and *Lithocarpus* also include susceptible species. To date, the disease has been found in 19 eastern and central states. The fungus spreads from tree to tree in local areas through root grafts and over long distances (overland) by various insect vectors. Local spread is prevented by severing grafted roots mechanically with root breakers or soil trenchers or chemically with soil fumigants and silvicides. Overland spread is reduced by the immediate destruction of diseased trees or by girdling deeply the base of their trunks to restrict or prevent the formation of fungus mats beneath the bark. Since known insect vectors infest fresh wounds, an added precaution is to avoid wounding oaks during the highly susceptible period of leaf expansion.

Erwinia nimipressuralis Carter Bacterial slime flux or wetwood (systemic in heartwood and inner sapwood)	Attacks many genera of trees including *Acer*, *Aesculus*, *Betula*, *Platanus*, *Populus*, *Quercus*, *Salix*, *Tilia*, and *Ulmus*, but appears to be most widespread and most injurious to elm.

C. Heart Rots

Many decay fungi destructively attack oaks. Heart rots account for a tremendous economic loss which often goes unrecognized until the tree is cut. Decay in oak is closely associated with wounds

whether, as in the case of "butt rots", with fire, logging, or grazing injuries, or in the case of "top rots", with trunk wounds, dead branches, or branch stubs. Moreover, the second-growth oak forests of the eastern, central, and southern states are largely of sprout origin and thus particularly vulnerable to butt rot initiated from parent stumps.

Reduction in extensive decay losses can be accomplished by proper management procedures. Definite measures are recommended for stands of sprout origin. Protection from fire, grazing, logging injuries, and other wounds; the early selective thinning of stump sprouts, improvement cuts to remove defective trees, avoiding of frequent cuts, the adjustment downward of the cutting age, and general measures to promote the growth and vigor of young trees will help minimize losses.

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Corticium spp. On dead wood and fallen branches, but sometimes associated with heart rot after fire damage.	
Corticium lividum Pers. ex Fr. Sprout butt rot	Q. borealis (19) and Q. palustris (23) in E.
Daedalea spp. Certain species reported on oak, mainly as slash and wood rotters, but occasionally associated with heart rot or wound rot of living trees.	
D. confragosa Bolt. ex Fr.	(1,4) in E and C.
D. quercina L. ex Fr.	(1,2,9,etc.) in E and C.
D. unicolor Bull. ex Fr.	(1,7,etc.) in E and C.
Fistulina hepatica Huds. ex Fr. Brown oak, red oak, "foxiness"; brown cubical heart rot; also sprout butt rot.	On both white and red oaks in E (1,4,9,19,20,24)
Fomes spp. Several species associated with heart rots and sap rots of living trees, but others mainly with wood rots.	
F. australis Cke.	(26,32)
F. calkinsii (Murr.) Sacc. & D. Sacc.	(26,32)
F. connatus (Weinm. ex Fr.) Gill	(1,19,etc.)
F. fomentarius (L. ex Fr.) Kickx.	(22,27) and several hardwoods.
F. fraxinophilus (Pk.) Sacc.	Mainly on Fraxinus.
F. geotropus Cke.	(26,28) and other hardwoods.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Fomes spp. (cont.)	
F. lobatus (Schw.) Cke.	(1-7,19,24,27,etc.)
F. marmoratus (Berk. & Curt.) Cke.	(26,28,etc.)
F. robustus Karst.	(19,28)
F. tenuis Karst.	(7)
Fomes applanatus (Pers. ex Wallr.) Gill. White mottled heart rot (butt and trunk)	On both white and black oak groups, especially in E (1-5,7,19-27,30, etc.).
Fomes everhartii (Ell. & Gall.) Schrenk White spongy heart rot (butt and trunk)	Trunk rot of living hardwoods, especially oaks; widely distributed; on both white and black oaks (1-6,9,10,13,17-25,etc.)
Fomes igniarius (L. ex Fr.) Kickx. White spongy heart rot (trunk)	Trunk rot of many living hardwoods, especially Acer, Betula, Fagus, and Populus; widely distributed; of great economic importance; on both white and black oaks (1-5, 7,9,19-22,27,32)
Ganoderma spp. Certain species cause root, butt, and trunk rots of living trees but are of minor importance in the United States.	
G. lucidum (Leyss. ex Fr.) Karst.	(20,22,26,28,32,etc.)
G. polychromum (Copeland) Murr.	(30)
G. sessile Murr.	(21,28)
Ganoderma curtisii (Berk.) Murr. White spongy heart rot (butt and trunk)	On both white and black oaks in E and S (1,19-23,26,29,32)
Hericium erinaceus (Bull. ex Fr.) Pers. White spongy heart rot (butt and trunk)	(1,9,10,26,28,29) Also, wound and sapwood rot (19,24)
Hydnum erinaceus Fr. White heart rot (butt and trunk)	(30) in California.
Hydnum velutinum Fr.	(1) in Pennsylvania.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks

Hymenochaete spp.
Mainly occur on dead wood, but sometimes associated with heart rot of living trees.
H. agglutinans Ell. (1,19,etc.)
H. corrugata (Fr.) Lév.
H. curtisii (Berk.) Morg. (1,4,5,7,27)
H. rubiginosa (Schrad. ex Fr.) Lév. (1-5,7,30,etc.)
H. tabacina (Sow. ex Fr.) Lév. (1,7,19)

Irpex spp.
Several species reported as wood rots of dead branches and logs; rarely associated with heart rots.

Lentinus spp.
Certain species on dead wood, but occasionally associated with wound rot, sapwood rot, and heart rot of living trees.

Lentinus tigrinus Bull. ex Fr. White mottled heart rot (butt and trunk)	Important decay of hardwoods in Mississippi River Delta Region (1,24,28)
Lenzites betulina L. ex Fr. Brown cubical heart rot	Mainly a wood rot of logs and stumps, but occasionally associated with heart rot of living trees, including both white and black oaks.

Merulius spp.
Several species cause wood rot of logs and slash, but sometimes are associated with heart rot of living trees.
M. rubellus Pk. (19-20) in E.
M. tremellosus Schrad. ex Fr. (1-5,10,19-24,28)

Pholiota adiposa Batsch ex Fr. Occasionally associated with a brown, mottled heart rot of living trees; also a sprout butt rot of oak.	General distribution on several tree species (20,etc.)

Pleurotus spp.
On dead wood, but sometimes associated with wound rots of living trees.

Causal Agent and Disease (cont.)	*Quercus* Species Affected, *U.S.* Occurrence, Remarks
Polyporus spp. Numerous species cause wood rot of logs and branches; sometimes also sapwood or heart rot of living trees; several species are associated with butt and trunk rots and together account for great economic loss in standing timber. *P. admirabilis* Pk. *P. adustus* Wilde ex Fr. *P. biformis* Klotzsch *P. caesius* Schrad. ex Fr. *P. cinnabarinus* Jacq. ex Fr. *P. compactus* Overh. *P. dichrous* Fr. *P. fissilis* Berk. & Curt. *P. gilvus* (Schw.) Fr. *P. glomeratus* Pk. *P. graveolens* Schw. ex Fr. *P. hirsutus* Wulf. ex Fr. *P. lucidus* Leyss. ex Fr. *P. ludovicianus* (Pat.) Sacc. & Trott. *P. pargamenus* Fr. *P. resinosus* Schrad. ex Fr. *P. rigidus* Mont. *P. robiniophilus* (Murr.) Lloyd *P. schweinitzii* Fr. *P. tulipiferus* (Schw.) Overh. *P. versicolor* L. ex Fr. *P. zonalis* Berk. Many other species mainly on dead wood.	
Polyporus berkeleyi Fr. White string heart rot (butt and trunk)	Many hardwoods including both white and black oaks in E (1-5,19-24,etc.)
Polyporus croceus Pers. ex Fr. White pocket rot, piped heart rot (butt and trunk)	Both white and black oaks in E (1,19,20,24,etc.)
Polyporus dryophilus Berk. White pocket rot, piped rot (trunk)	Widespread, especially in SW and W on oaks and occasionally poplars (1,7,10,19,20,24,30,etc.)
Polyporus frondosus Dicks. ex Fr. Yellowish spongy heart rot (butt)	In E, on oaks and chestnuts (1-5,9,19,20,22,etc.)

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Polyporus hispidus Bull. ex Fr. White spongy heart rot (butt and trunk) and trunk canker (can become parasitic on sapwood)	Especially on black oaks in E and S (1,9,19,20,24,26,29,etc.)
Polyporus obtusus Berk. White spongy heart rot	Locally destructive in E and C in hardwoods, especially oaks (1,6,19,22,24,25,27,etc.)
Polyporus rheadus (Pers.) Fr. White pocket rot, white spongy root and butt rot	NE, C, and SW (1-10,13-15, 19-24,27-29,30-33)
Polyporus spraguei Berk. & Curt. Brown **crumbly** heart **rot** (root, butt, and trunk)	Of chestnut, persimmon, and oak (7,9,10,19-24,27,etc.) in E, C, W.
Polyporus sulfureus Bull. ex Fr. Brown cubical heart rot (butt and trunk)	Widespread; in living conifers and hardwoods, especially both white and black oaks (1-5,7, 19-24,26,28,30-33,etc.); very prevalent, serious, and causes considerable economic loss.
Poria spp. Numerous species cause wood rot of fallen trunks and branches; a few are associated with heart rots of living trees.	
Poria andersonii (Ell. & Ev.) Neuman White spongy heart rot	**Widely** distributed; in hardwoods especially both white and black oaks (1-8,19,20,24, 28,30,etc.)
Poria cocos (Schw.) Wolf Brown root and butt rot	In conifers and hardwoods in E and S (1,19,20,24,29).
Poria inflata Overh. Brown heart rot	(9,28)
Poria spiculosa Campbell & Davidson White trunk rot (may cause canker)	(22,27,28,29)

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Stereum spp.	
Several species are associated with butt and trunk rot of living oaks, while others occur generally on dead wood of logs, branches, and stumps but sometimes as heart rot of trees.	
S. *albobadium* (Schw.) Fr.	(1)
S. *complicatum* (Fr.) Fr.	Several white and black oaks.
S. *fascicatum* Schw.	"
S. *fuscum* Schrad. ex Quél.	"
S. *hirsutum* Willd. ex Fr.	"
S. *murrayi* (Berk. & Curt.) Burt	(1,etc.)
S. *purpureum*	
S. *rameale* Schw.	Several white and black oaks.
S. *sericeum* Schw.	(1)
S. *umbrinum* Berk. & Curt.	Several white and black oaks.
S. *versiforme* Berk. & Curt.	(1)
Stereum frustulosum (Pers.) Fr. White pocket heart rot (butt and trunk)	(1,9-11,19-24) in E and C.
Stereum gausapatum (Fr.) Fr. White pocket heart rot (root, butt, and trunk)	Common in sprout stands of both white and black oaks in E (1-6,9,11,19-24,27,28,etc.)
Stereum subpileatum Berk. & Curt. White pocket heart rot (butt and trunk) "honeycomb rot"	Common in sprout stands of both white and black oaks in E, SE, and S (1-6,9,19-24,27, 29,32,etc.).

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Collybia velutipes Fr. Sapwood rot	Soft, spongy white rot of sapwood of living hardwoods including *Quercus* sp. in Pa., and *Q. borealis* (19) in Ind.

D. Miscellaneous

1. Bark Patch

Aleurodiscus spp., including
- A. *acerinus* (Pers. ex Fr.) Hoehn. & Litsch.
- A. *candidus* (Schw.) Burt
- A. *disciformis* (DC. ex Fr.) Pat.

Causal Agent and Disease (cont.)	Quercus Species Affected, U.S. Occurrence, Remarks
Aleurodiscus spp. (cont.) *A. dryinus* (Pers.) Bourd. *A. griseocanus* (Bres.) Hoehn. & Litsch. *A. oakesii* (Berk. & Curt.) Cke. Bark patch, smooth patch, smooth bark (see also *Corticium maculare* Lair) Superficial; outer rough, dead bark sloughs off leaving smooth, grey, depressed areas.	Common on eastern white oaks; also reported on red oaks; little injury.
Corticium maculare Lair Smooth patch	*Q. alba* (1) and *Q. stellata* (5) in N. Carolina.

2. Galls

Agrobacterium tumefaciens (E. F. Smith and Town.) Conn. Crown gall	Occurs commonly on roots of many plants, including trees and shrubs, but also may develop on crowns, stems, and even leaves; occasionally on oak transplant stock. Control is chiefly through production of clean nursery stock.
Phomopsis spp. Galls	On trunk and branches of several hardwoods including oak, especially black oaks (1,4,5, 24,etc.) in E, C, and S.

3. Stains

Ceratocystis spp. Blue stain	Sapwood stain of many conifers and hardwoods; also of logs and lumber.
Geotrichum sp. Pink stain	Both heartwood and sapwood stain of several conifers and hardwoods, including oak.
Graphium rigidum Pers. ex Sacc. Sapwood stain	(19,20)
Graphium rubrum Rumbolt Sapwood stain	(1,3,19)
Penicillium sp. Yellow stain	Yellow stain of wood of several hardwoods including oak.

4. American Mistletoes

The semiparasitic "true or leafy" mistletoes of the genus *Phoradendron* attack mainly hardwoods, including oaks, but usually cause little serious damage to forest trees except those with slow growth and low vigor. Infected branches suffer various hypertrophies and may die beyond the point of infection. The sticky seed are distributed largely by birds. Only young, thin bark is penetrated.

In forest stands, infected trees should be removed. Infected branches can be pruned from shade trees.

Intercontinental spread is possible though several factors probably would deter establishment, including susceptibility limited to young tissue, slowness of disease development, relatively easy and early recognition, and possibility of eradication.

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Phoradendron flavescens (Pursh) Nutt. (*P. flavescens* (Pursh) Nutt. var. *glabriusculum* Engelm.) Eastern mistletoe	(1,3,4,5,22,24-29,etc.) in E, C, and S.
Phoradendron villosum Nutt. (*P. flavescens* var. *villosum* (Nutt.) Engel.) Hairy mistletoe	Chiefly on Pacific Coast on various hardwoods, especially oaks (7,8,14,30,31,33,etc.)

ROOT ROTS

Root diseases affect both conifers and hardwoods in the nursery, plantation, or natural stand. They destroy roots; lower tree vigor; contribute to general decline, branch dieback, and stagheading; subject trees to windthrow; and cause considerable mortality especially in the nursery and plantation (most alarming in coniferous plantings). In addition, incipient infections may predispose trees to other pathogens. These disorders often are associated with adverse edaphic, environmental, or "stress" factors. They are difficult to diagnose because initial attack is below ground, because different fungi may be involved, because secondary organisms quickly appear, because symptoms are nonspecific,

and because it is hard to reproduce typical disease symptoms with particular organisms. Much information is needed regarding these diseases, the causal organisms, and how they operate.

So far, general control measures include the avoidance of root injuries, minimizing of adverse conditions, and maintenance of tree vigor and good growth.

Intercontinental spread is possible on infected transplants and, in the case of nematodes, also in infested soil transported with plants.

Causal Agent and Disease	Quercus Species Affected, U.S. Occurrence, Remarks
Armillaria mellea (Vahl. ex Fr.) Quél. Armillaria root rot, shoestring root rot, oak root rot, honey mushroom root rot; also white spongy butt rot, crown rot, collar rot	Widespread; common on many trees (both conifers and hardwoods), shrubs, and other plants; attacks oaks commonly, especially weakened trees, and contributes to general decline, branch dieback, and stagheading. Can incite severe deterioration of oak in many situations.
Clitocybe tabescens (Scop. ex Fr.) Bres. Clitocybe mushroom root rot	A destructive disease of fruit, forest, shade, and ornamental trees including both conifers and hardwoods; mainly in SE; attacks both red and white oaks; similar to and often confused with Armillaria root rot.
Corticium galactinum (Fr.) Burt Stringy yellow butt and root rot	Of conifers and hardwoods including oaks in E.
Fomes annosus (Fr.) Cke. White spongy root and butt rot.	Occasionally on hardwoods including oaks (6,9,etc.)
Phymatotrichum omnivorum (Shear) Dug. Phymatotrichum root rot	This soil fungus attacks many dicotyledonous plants, including trees and shrubs which exhibit reduced growth and vigor, thinning of crown, and progressive deterioration; indigenous in SW; serious in shelterbelt plantings; avoided by planting resistant tree species (4,10,22,23,32,34).

Causal Agent and Disease (cont.)	*Quercus* Species Affected, U.S. Occurrence, Remarks
Polyporus dryadeus Pers. ex Fr. White root rot, white root and butt rot	(1,10,19-25,28) in E.

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Conopholis americana (L.f.) Wallr. "sqaw root"	Parasitic phanerogam on roots of certain oaks in E.

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Hoplolaimus coronatus Cobb Root nematode	(19,23) in NE.
Meloidogyne sp. Root knot nematode	(30,36) in California.
Pratylenchus sp. Meadow nematode	(19,23) in Maryland.

NONINFECTIOUS DISEASES

Oaks suffer from many of the "nonparasitic" or "physiological" diseases that damage other trees: "too much or too little" of any number of environmental factors as water, nutrients, temperature, and light.

Iron chlorosis Deficiency or nonavailability, especially in alkaline soils.	Primarily affects pin oak (23) in N. Carolina, and elsewhere.

UNKNOWN DISEASES

Oak dieback	Dieback and death of red oaks on occasional trees or in many trees over large areas in NE.

DISEASES OF ROBINIA[1]

by

Thomas S. Buchanan[2]

Importance of the Genus

From the forestry standpoint Robinia can be considered monotypic. While there are at least seven or eight and possibly as many as ten or eleven taxonomically recognizable species in the genus, all limited in natural range to the United States or Mexico, only four or five species reach tree size. Of these, black locust (*Robinia pseudoacacia* L.) alone is of importance as a forest or timber tree and its natural range is restricted to the U.S.A. The question of types or strains is raised from time to time but only one clonal line, the so-called shipmast locust (*R. ps.* var. *rectissima* Raber), described originally from Long Island, New York, seems to warrant such recognition.

Black locust is particularly valued for posts and poles because of the high decay resistance of its heartwood. The wood is also sought for specialty uses calling for the additional attributes of hardness, high strength, stiffness, shock resistance, nail-holding ability, and low shrinkage. As a tree, it is especially useful for erosion control, preventing sand drift, and, because of its nitrogen-fixing capacity, for site rehabilitation and improvement. It is also commonly used for reclaiming spoil banks where tolerance to an atmosphere polluted with smoke and dust may sometimes be required. Black locust reproduces itself vigorously by seed and through root sprouting, and nursery-grown seedlings are quite easily and successfully transplanted. It is widely planted in woodlots for fence posts and fuelwood, and, because of its drought resistance and adaptability to calcareous soils, in shelterbelts and windbreaks. In all these uses added benefits accrue by virtue of the cover and food provided for domestic animals and wildlife and as a source of floral nectar for honey bees. Black locust is also widely planted for shade and ornamental purposes.

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forest Service, U.S. Department of Agriculture, Washington, D.C.

These many desirable attributes have led to tremendous artificial extension of the range of Robinia pseudoacacia. Originally black locust was limited to the Appalachian region of the United States from south-central Pennsylvania south to northern Georgia and northeastern Alabama and a limited area in the Ozark Mountains of southern Missouri, northwestern Arkansas, and eastern Oklahoma. Through planting, the tree is now found in practically every state in the Union and in at least forty countries throughout the world. It has become naturalized in many of them. Introductions into Europe began as early as the 17th century. Planting has been most common in those countries north of the Tropic of Cancer but below latitude 60° N. and in those south of the Tropic of Capricorn but below latitude 50° S. Planting records for the truly tropic and arctic regions are but rarely encountered.

Present and Potential Disease Impact

Although black locust may thrive on alkaline soils it is often subject to chlorosis, especially in the nursery, if certain salts are present. Chlorotic seedlings fail to harden off properly in the fall and may therefore be injured by early frosts.

There are indications that planting of black locust in mixture with other species should be approached with caution lest certain abiotic diseases be induced. The complete elimination of white pine near locust trees in certain areas suggests that the roots of this legume may secrete toxic substances, an apparent antagonism comparable to the more familiar toxicity of black walnut. As another example, trunk splitting (frost cracks) has been common in Michigan plantations of Norway spruce in mixture with black locust. Pure stands of spruce in the same forest suffered no such damage. Ecological competition may, however, explain the first situation and stimulation of the growth of spruce the latter.

There are also reports of black locust in mixed plantings both encouraging and discouraging biotic diseases on associated species. In Austria, for example, an outbreak of needle disease was more damaging to Austrian pine where mixed with black locust. Presumably this was because of the increased susceptibility of the luxuriant pine shoots developed in response to the increased nitrogen content of the soil induced by the black locust. Conversely, red pine plantings in Michigan were little damaged by needle rust when black locust was growing nearby. The explanation here was that the increased growth rate of the pines shortened the period during which they were subject to damage.

Robinia pseudoacacia has obviously been widely exposed over many years to a variety of environments and potential disease hazards.

The pathology of the species is therefore quite well known. The specific records that follow show that black locust is host to many pathogens, one or more of which may be damaging to various parts of the tree, and to which the species may be susceptible at all stages of life, from seedling to maturity. For a species whose heartwood is so durable in use, it is surprizing to find so many decay fungi recorded as occurring on the living tree. Fortunately, however, perusal of available literature has disclosed record of no disease that would seem to pose any special threat to the continued survival of the species or that appears even critically to impair its usefulness. Essential detail is given only for those few diseases where the name of the causal organism may not, in itself, serve fully to indicate whether it is innocuous or has potential importance.

SEEDLING DISEASES

Any organism capable of damaging nursery seedlings must be considered potentially important where climatic and edaphic factors are favorable for its development. Good nursery practices, seed treatment, and soil fumigation can do much to minimize possible losses.

Causal organism and type of damage	Reported from:
Alternaria sp. Seedling leaf blight	USA
Colletotrichum glycines Hori Anthracnose of seedlings	Japan
Cuscuta arvensis Beyr. Dodder	USA
Cuscuta epithymum Murray Dodder	Yugoslavia
Cuscuta europaea L. Dodder	Yugoslavia
Cuscuta gronovii Willd. Dodder	Yugoslavia
Cuscuta pentagona Eng. Dodder	Yugoslavia
Fusarium herbarum Cda. ex Fr. Wilt, dieback	Germany
Fusarium pseudoacacia Rapaics Wilt, dieback	Hungary

Fusarium sambucinum var. coeruleum Wr. Wilt, dieback	Germany
Fusarium sp. Seedling root rot	USA
Fusicladium robiniae Shear Seedling leaf blight	USA
Guignardia robiniae Ito & Kobayashi (syn. Gloeosporium revolutum; Colletotrichum destructivam O'Gara imp. stage) Anthracnose. Seedling disease from internally infected seed. Also on saplings and mature trees.	Japan
Macrophomina phaseoli (Maubl.) Ashby (Sclerotium bataticola Taub.) Seedling stem rot	USA
Macrosporium sp. Leaf spot of seedlings	USA
Meloidgyne spp. Root knot nematodes	USA
Pellicularia filamentosa (Pat.) Rogers Web blight of seedlings	Japan
Phyllosticta neomexicana Bub. & Kab. Leaf spot (on R. neomexicana)	Czechoslovakia
Phytophthora cactorum (Leb. & Cohn) Schroet. Seedling blight, crown canker	Germany, Gt. Brit., Hungary
Phytophthora cinnamomi Rands Seedling root rot	USA
Phytophthora citrophthora (R. E. & E. H. Sm.) Leon. Root rot	Argentina, USA
Phytophthora parasitica Dast. Seedling top wilt	USA
Pratylenchus sp. Root nematode	USA

Pythium myriotylum Drechs. Seedling root rot	USA
Pythium ultimum Trow Damping-off	USA
Pythium spp. Damping-off	Greece, USA
Rhizoctonia bataticola (Taub.) Butl. Seedling stem rot	USA
Rhizoctonia solani Kuehn Damping-off, seedling leaf blight	Argentina, Japan, USA

ROOT DISEASES

Root diseases are of potential importance, at least locally, once a plantation becomes infested. Since extensive direct controls are generally impractical, prevention through proper site selection and planting only disease-free stock is the best insurance.

Causal organism and type of damage	Reported from:
Armillaria mellea (Fr.) Quél. Shoestring root rot	Denmark, France, Italy, USA
Fomitopsis semilaccatus S. Ito Root (and butt) rot	Japan
Helicobasidium mompa Tanaka Violet root rot One of the most important soil-borne diseases in Japan and black locust listed as very susceptible where planted there. Purple rhizomorphs on the surface of roots and lower trunk and purplish-brown (in spring), sessile, resupinate, velvety sporophores on basal trunk serve to identify the causal organism. Kills fine roots and, when severe, the cambial portion of larger roots resulting in smaller, yellowish foliage, premature leaf fall, and eventual death. No effective controls known.	Japan
Phymatotrichum omnivorum (Shear) Dug. Texas root rot	USA
Thielavia basicola Zopf On dead roots (probably follows Thielaviopsis)	USA

STEM DISEASES

None of the canker diseases recorded are known to be aggressive parasites on black locust. No records of rusts have been encountered. Though many heart rots have been noted for black locust, they are of importance only when the tree is grown to older ages for saw- or veneer-log production. In soil stabilization, site improvement, fuel wood production, and similar uses, heart rots are not critical factors. Mistletoes parasitizing black locust present no different problems than on other hardwood species.

Cankers and Diebacks

Causal organism and type of damage	Reported from:
Aglaospora anomia (Fr.) Lamb. (*A. profusa* de N.) Canker, twig blight	Belgium, Netherlands, Portugal, USA
Botryosphaeria dothidea (Moug.) Ces. & de N. On branches	Netherlands
Botryosphaeria ribis Gross. & Dug. On branches	USA
Calonectria dearnessi Ell. & Ev. On branches	USA
Camasporium pseudoacacia Brun. On branches	Czechoslovakia, Denmark, France, Italy, Portugal, Rumania, USSR
Coryneum trimerum Sacc. On branches	USA
Cryptosporium robiniae Dearn. & House On twigs	USA
Cucurbitaria elongata (Fr.) Grev. Widespread on branches; reported on roots in USSR	Austria, Canada, Denmark, France, Germany, Hungary, Italy, Netherlands, Poland, Rumania, Spain, USA, USSR
Cytospora chrysosperma Pers. ex Fr. Cankers on twigs and limbs	Chile

Cytospora ludibunda Sacc. (Cytosporina ludibunda Sacc.)	Denmark, Germany, Rumania
Diaporthe fasciculata Nits. (Diaporthe oncostroma (Duby) Fckl.; reported under Phomopsis oncostoma (Thuem.) Hoehn., and several other names). Canker, dieback caused by Phomopsis stage	Argentina, Austria, Belgium, Czechoslovakia, Denmark, France, Germany, Gt. Brit., Hungary, Italy, Netherlands, Rumania, USA, USSR, Yugoslavia
Diplodia profusa de N. On branches and dead twigs	India, Italy, Germany, Rumania, USSR
Dothiorella glandulosa (Cke.) Sacc. On branches	USA
Dothiorella robiniae Prill. & Del. On branches	France, Portugal
Fusarium avenaceum (Fr.) Sacc. On twigs	USA
Fusarium sarcochroum (Desm.) Sacc. Twig canker	USA
Gibberella baccata (Wallr.) Sacc. (Fusarium lateritium Nees) On twigs; severe damage to nursery stock in Japan	Denmark, France, Germany, Japan, Netherlands, Portugal, USA, USSR
Macrophoma numerosa Pk. On branches	USA
Melanconium viscosum Schw. On dead branches	USA
Nectria cinnabarina Tode ex Fr. Hardwood branch dieback	Austria, China, Czechoslovakia, Germany, Netherlands, Rumania, USA, USSR, Yugoslavia
Phoma labens Sacc.	Rumania
Physalospora obtusa (Schw.) Cke. On branches	Rumania, USA
Pseudovalsa profusa (Fr.) Wint. Necrosis of bark and branches	Czechoslovakia, Denmark, Germany, Poland, Rumania, USSR

Rhabdospora breviuscula (Berk. & Curt.) Sacc. On branches	Denmark, USA
Valsa heteracantha Sacc.	Rumania
Valsa ceratophora Tul.	USA

Heart Rots

Causal organism and type of damage	Reported from:
Daedalea ambigua Berk. White sap rot	USA
Daedalea confragosa Bolt. ex Fr. White rot	Rumania
Daedalea quercina L. ex Fr. Brown cubical rot	Rumania
Daedalea unicolor Bull. ex Fr. Trunk rot	Gt. Brit., Hungary, Rumania, USA
Fomes connatus (Weinm.) Gill. White spongy heart rot	Gt. Brit., USA
Fomes fraxineus (Bull. ex Fr.) Cke. Soft white heart rot	Gt. Brit., Rumania, USA, USSR, Yugoslavia
Fomes ignarius (L. ex Fr.) Kickx (including vars. _laevigatus_ (Fr.) Overh. and _populinus_ (Neuman) Campbell) White heart rot	Rumania, USA, USSR
Fomes robiniae (Murr.) Sacc. & D. Sacc. (_F. rimosus_ (Berk.) Cke.)	Chile, Dominican Republic, Jamaica, Germany, Pakistan, USA

Causes a spongy yellow heart rot of living black locust throughout the range of the tree in the USA.

Infection occurs through older branches and _through tunnels made by the locust borer_ (_Megacylene robiniae_ Forst.). Wood is eventually reduced to a soft spongy yellow or brown mass. Red-brown mycelial felts characterize the decay. Presence of the perennial large, brown, hard, woody conks on a tree indicate extensive decay. (Does not continue on wood in use).

Fomes robustus Karst. White trunk rot	Australia, USA
Ganoderma applanatus (Pers. ex Wallr.) Pat. White mottled heart rot	Rumania, USA
Ganoderma curtisii Murr. Root and trunk rot	USA
Ganoderma lucidum (Leys. ex Fr.) Karst. Heart rot	Argentina, Rumania, USA, Yugoslavia
Hericium erinaceus (Fr.) Pers. White heart rot	USA
Irpex mollis Berk. & Curt. White heart rot	USA
Leptoporus litschaueri (Lohw.) Pilát	Rumania
Phellinus torulosus (Pers.) Bourd. & Galz.	Rumania
Pholiota squarrosa (Batsch ex Fr.) Kumm.	Germany
Pleurotus ostreatus (Jacq.) Fr. Heart rot	Poland, Rumania
Polyporus biformis Fr. Heart rot	USA
Polyporus gilvus (Schw.) Fr. White rot of heartwood and dead sapwood	USA
Polyporus lucidus (Leyss.) Fr.	USA
Polyporus obtusus Berk. White heart rot	India, USA
Polyporus rhodophaeus Lév. Root and butt rot	Japan
Polyporus robiniophilus (Murr.) Lloyd White spongy heart rot of living trees	China, USA

Polyporus sulphureus Bull. ex Fr. Brown cubical heart rot	Denmark, France, Germany, Japan, Rumania, USA
Poria ambigua Bres. (*Poria latemarginata* (Dur. & Mont.) Cke.)	Hungary, Rumania, USA
Trametes trogii Berk. Trunk rot	Argentina
Xylaria longeana Rehm Wood rot, usually on stumps or dead trunks	USA
Xylaria polymorpha (Pers.) Grev. Wood rot, usually on stumps or dead trunks	USA

Mistletoes

Causal organism and type of damage	Reported from:
Phoradendron flavescens (Pursh) Nutt. var. *glabriusculum* Engelm. Eastern mistletoe	USA
Phoradendron flavescens (Pursh) Nutt. var. *macrophyllum* Engelm. Mistletoe	USA
Viscum album L. European mistletoe	Czechoslovakia, France, Poland

FOLIAGE DISEASES

As a class, foliage diseases of hardwoods are not particularly damaging unless severe and repeated defoliation results. Direct controls are generally not feasible for forest trees.

Causal organism and type of damage	Reported from:
Alternaria fasciculata (Cke. & Ell.) Jones & Grout Leaf spot	USA
Alternaria tenuis Nees Leaf spot	Yugoslavia

Ascochyta robiniae Sacc. & Speg. Grayish leaf spot; ring spot.	Gt. Brit., Italy
Cladosporium epiphyllum Pers. ex Fr. Leaf spot	Palestine, USA
Colletotrichum destructivum O'Gara Anthracnose; seedlings, saplings, mature trees	Japan
Coniothyrium fuckelii Sacc.	Rumania
Cylindrosporium solitarium Heald & Wolf Leaf spot	USA
Ectostroma robiniae Cast.	Rumania
Erysiphe communis (Wallr.) Link f. robiniae Tschern. On upper leaf surfaces	USSR
Erysiphe martii Lév. Leaf spot, mildew	France, Germany, Rumania
Erysiphe polygoni DC. Powdery mildew on leaves	Gt. Brit., Italy, Japan, Rumania, USA, Yugoslavia
Gloeosporium revolutum Ell. & Ev. Leaf spot	USA
Guignardia robiniae Ito & Kobayashi Anthracnose; seedlings, saplings, and mature trees. Seedling disease from internally infected seed.	Japan
Heterosporium robiniae Kab. & Bub. On leaves	USA
Microsphaera bäumleri Magunus Powdery mildew	Japan
Microsphaera diffusa Cke. & Pk. Powdery mildew	Japan, USA
Phleospora robiniae (Lib.) Hoehn Leaf spot	Czechoslovakia, France, Germany, Gt. Brit., Hungary, Italy, Poland, Rumania, Spain, USA, USSR

Phyllactinia corylea Pers. ex Karst. Powdery mildew	USA
Phyllosticta advena Pass. Leaf spot	Spain, USSR
Phyllosticta pseudoacacia Pass. Leaf spot	France
Phyllosticta robiniae Sacc. Leaf spot	France, Italy, USA
Septoria curvata (Rab. & A. Braun) Sacc. Brown leaf spot	Germany, Gt. Brit., Italy, Poland, USA, USSR
Septoria pseudoacacia C. Mass. Leaf spot	Italy
Sphaerella pseudoacacia Auers. Leaf spot, on petioles	Germany, Italy
Sphaerella robiniae Siem. Leaf spot	USSR

SYSTEMIC DISEASES

The brooming disease is one of the few known virus diseases of forest trees. Prevention is the only practical control; cuttings should be taken only from the stems or roots of disease-free stock when reproducing black locust vegetatively. Only one vascular wilt of importance to the species and no systemic dieback diseases have been reported.

Viruses

Causal organism and type of damage	Reported from:
Chlorogenus robiniae Holmes (Polycladus robiniae McK.) Witches' broom, brooming virus, brooming disease	Bulgaria, France, USA

Known since 1898 and widely distributed in eastern USA. All degrees of brooming from severe to symptomless carriers. Vein-clearing, reduction in leaf size, and brooming prominent symptoms. Results in trees with poor branching habit and sometimes death of all or part of the plant. Transmissible through stem or root cuttings. Consequences most serious under poor growing conditions.

Vascular Wilts

Causal organism and type of damage	Reported from:
Verticillium albo-atrum Reinke & Berth. Verticillium wilt	Italy, Netherlands, USA

It should be borne constantly in mind that black locust is a member of the Leguminosae, one of the larger plant families whose many genera and species occur naturally throughout the world. Arborescent representatives of the family are especially common in the Tropics. Diseases of generally relatively minor importance on black locust may, therefore, constitute a more serious threat to certain other closely related forest trees having much greater local economic significance.

DISEASES OF SWIETENIA[1]

by

J. R. Hansbrough and B. K. Bakshi[2]

The genus *Swietenia* is a small one indigenous to the tropical Americas, between latitudes about 26°N. in the Bahamas and southern United States and about 18°S. in extreme western Brazil. Most authorities recognize three distinct species, though six others have been named and later reduced to synonomy, as follows:

- *S. mahagoni* Jacq.
- *S. macrophylla* King
  - *S. aubrevilleana* Steh. & Cusin
  - *S. belizensis* Lund.
  - *S. candollei* Pitt.
  - *S. krukovii* Gleas. & Pansh.
  - *S. tessmannii* Harms
- *S. humilis* Zucc.
  - *S. cirrhata* Blake

Swietenia mahagoni is native to the West Indies (Bahamas, Cuba, Jamaica, Hispaniola) and southernmost United States (Florida Keys and mainland near Cape Sable). It grows to 100 feet in height and 15 feet in girth above the massive buttressed base. It is recognized as one of the best cabinet woods in the world and is highly valued for furniture, musical instruments, and interior building finish.

Swietenia macrophylla is native in regions of abundant rainfall from southern Mexico through Central America to western Brazil. It grows to 130 feet in height and 20 feet in girth. It is the most widely distributed species of the genus, from sea level to 4500 feet elevation with annual rainfall from 60 to 200 inches and temperatures from 11°-37°C. The wood is generally somewhat coarser than in *S. mahagoni* but as the latter species becomes less and less common, *S. macrophylla* supplies more and more of the true mahogany of commerce.

Swietenia humilis is native in the drier areas along the Pacific

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forest Service, U. S. Department of Agriculture, Washington, D. C., and Forest Research Institute, Dehra Dun, India, respectively

Coast from southwest Mexico to Costa Rica. It is a small tree of little commercial importance.

The two mahoganies, _S. macrophylla_ and _S. mahagoni_, are considered to be among the most valuable timber trees in tropical America. They have been widely planted not only within their native ranges but also in the tropical regions of other continents. Because of its faster growth and better response to nursery and plantation practices, _S. macrophylla_ has been planted much more commonly and widely than _S. mahagoni_.

Current management practices to improve the quantity and quality of mahogany consist mainly of (1) thinning natural stands to promote regeneration and to favor advance reproduction, (2) release of seedlings around stumps of felled trees to take advantage of the heavy regeneration that occurs within two years of felling, and (3) planting cleared land with nursery-produced seedlings. The seedlings transplant easily, particularly _S. macrophylla_, and make excellent growth, producing merchantable-sized logs in 30 years under favorable conditions. The rotation age under average conditions should not exceed 60-65 years.

There are few references in the literature to diseases in natural stands and plantations of mahogany. This may mean that diseases are not now and with proper care may not become a limiting factor in mahogany production but it is more likely that disease losses have simply not been observed and reported. In the past the mahogany of commerce has been secured largely from trees grown in unmanaged stands. Under such conditions little attention has been given to the causes of loss of trees below merchantable size. In naturally regenerated managed stands and even more in intensively managed plantations, it is probable that in the future many diseases now unknown or unreported will be found causing serious losses to mahogany.

The relatively few diseases that have been recognized and reported in the past are as follows:

SEED AND SEEDLING DISEASES

Diplodia theobromae (Pat.) Howell — Storage rot of seed

Reported in Philippines and Fiji on seed of _Swietenia macrophylla_ stored for three weeks at room temperature and humidity. Under dry storage in sealed containers at temperatures of 1°-4°C., seed can be stored for four months or longer without serious loss of viability.

Nectria discophora Mont. — Seed disease

Reported in Trinidad on _Swietenia mahagoni_ — Parasitic on seed capsules.

Phyllosticta swieteniae Alvarez Garcia — Seedling blight

Reported in Puerto Rico on 6-months-old Swietenia mahagoni seedlings in nursery. Leaf tips and margins, later entire leaves, turn yellow to dark brown. Small, black, erumpent fruiting bodies form on dead areas. Disease caused heavy losses in beds with high seedling density that were shaded and sprinkled during night. Control recommendations are to lower seedling density, reduce shade and sprinkle only in daytime as needed.

Rhizoctonia solani Kuehn — Seedling dieback

Reported in Java on Swietenia macrophylla as possible cause of dieback of seedlings in shaded seed beds. Similar symptoms in unshaded seed beds were attributed to heat injury.

Sclerotium delphinii Welch — Seedling wilt

Reported in Philippines on Swietenia macrophylla as cause of serious rot of seed and wilt of seedlings in seed bed. No control recommendations given. Some mycologists consider this fungus to be identical with or a form of Sclerotium rolfsii, see below.

Sclerotium rolfsii Sacc. — Seedling wilt

Reported in Philippines on Sindora supa Merr. as emergence wilt of seedlings. Pathogenicity to Swietenia mahagoni demonstrated by inoculations. Natural infection of S. mahagoni reported in Ceylon. Losses may be prevented by proper soil tillage and drainage, sowing during drier part of year, and avoiding heavy watering. Susceptible hosts should not be sown in infested beds for some time.

ROOT DISEASES

Fomes fastuosus (Lév.) Cke. — Root and butt rot

Reported in India on Swietenia macrophylla and S. mahagoni. Causes butt rot and wind throw. Fruiting bodies perennial, woody, medium sized, sessile to substipitate, conchate to applanate; upper surface dull brown to black, zonate, and sometimes sulcate; context yellow; spores subglobose, yellow. Causes large honeycomb pockets filled with white decayed fibers, later pockets empty and dark brown. Control through prevention of basal wounds that serve as infection courts. In India this fungus has a wide range of hosts, including Shorea robusta Gaertn. on which it causes a serious heart rot.

Fomes lamaoensis (Murr.) Sacc. & Trott. Brown root rot

Reported in Ceylor and Java on *Swietenia macrophylla* and *S. mahagoni* as cause of serious root rot and death of infected trees. Fruiting bodies perennial, woody, medium sized, sessile, flat, thin, imbricate, with upper surface zonate and horny incrusted. Diseased roots covered with mat of brown mycelium enclosing soil and debris. Infected bark brown or mottled with white patches. Causes large honeycomb pocket rot of wood. Infection can be prevented by application of a fungicide to the root collar of healthy trees. Pathogen reported on other hosts in Africa, South America and West Indies.

Fomes noxious Corner Root rot

Reported in Java on *Swietenia macrophylla* and *S. mahagoni* as a root rot attacking plantation trees. No control recommendations given. Some mycologists consider this fungus to be identical with or a form of *Fomes lamaoensis*, see above. Others consider it to be a distinct entity.

Tylenchus mahogani Cobb Root nematode

Reported in Barbados on *Swietenia mahagoni*. Parasitic on bark tissues.

Xiphinema sp. Root nematode

Reported (personal communication) in Puerto Rico on *Swietenia mahagoni* roots, causing sufficient root mortality to be responsible for twig and branch dieback in crown but association not proved. Many free-living nematodes in rhizosphere also.

STEM DISEASES

Corticium salmonicolor Berk. & Br. Pink disease

Reported in Java on *Swietenia macrophylla* and *S. mahagoni*. Attacks twigs, branches and stems. Infects through lenticels and bark wounds. White or pink pustules appear on killed bark, followed by a pink mycelial growth which precedes the formation of the typical salmon-colored resupinate fruiting body. Basidiospores are globular, 6-11.5 microns in cross section, and easily released for dispersal by wind or rain. Frequently girdles infected parts, killing the distal portion. Wood under infected bark dark brown in color. No control recommendations.

Dothiorella mahagoni Thüm. Black stem rot

Reported in India and West Indies on *Swietenia mahagoni*. Causes black spots on stem in which dark brown pycnidia develop. Spores

large, elliptic, hyaline to pale yellow. No control recommendations.

Fomes durissimus Lloyd — Trunk rot

Reported in India on Swietenia mahagoni. Causes heart rot in standing shade trees. Fruiting bodies perennial, hard, woody, sessile, large, upper surface brown to black, context yellow, spores pale brown, sub-globose. This fungus attacks a wide range of hardwoods.

Dendropemon brevipes Britt. — Mistletoe

Reported in Bahamas on Swietenia mahagoni.

Dendrophthoe falcata (L.f.) Ettings. — Mistletoe

Reported in India on Swietenia macrophylla.

Loranthus sp. — Mistletoe

Reported in Indonesia on Swietenia mahagoni.

Phoradendron haitiense Urb. — Mistletoe

Reported in Dominican Republic on Swietenia mahagoni.

Phoradendron rubrum (L.) Griseb. — Mistletoe

Reported in United States (Florida) on Swietenia mahagoni. Causes witches'-brooms 2-3 feet in diameter. Abundant on large dead trees and presumably involved in their death.

Phoradendron serotinum (Raf.) Johnst. — Mistletoe

Reported in United States (Florida) on Swietenia mahagoni. In the absence of information on symptoms or damage, it may be assumed that these mistletoes cause witches'-brooms on infected branches and may result in death of affected parts.

Canker (Cause unknown)

Reported in Trinidad on Swietenia macrophylla and S. mahagoni. Common on stem and branches of trees of all ages. Damage heavy. No control recommendations.

FOLIAGE DISEASES

Cephaleurous virescens Kunze — Red rust

A parasitic alga reported on Swietenia mahagoni from India (Bengal) and Sudan (as C. mycoidea, presumably identical with C. virescens). Damage not known. A similar alga, C. mycoidea Karst., parasitises many hosts and causes serious injury to tea and mango plants, particularly when it attacks young woody shoots.

Cercospora subsessilis Sydow — Leaf spot

Reported in India, Peru and Puerto Rico on Swietenia mahagoni and S. macrophylla. Spots 2-5mm. in diameter, zonate, tan, pale brown or gray. No additional information available.

Colletotrichum gloeosporioides Penz. — Anthracnose

Associated with leaf spots and twig blights throughout tropics on mahogany and innumerable other species.

Meliola swietenia Cif. — Black mildew

Reported in Dominican Republic on Swietenia mahagoni. Causes black patches on upper surface of leaves.

Pestalotia swieteniae Gonz., Frag. & Cif. — Leaf spot

Reported in Dominican Republic and United States (Florida) on Swietenia mahagoni. Causes large, irregular, marginal or apical, reddish later gray lesions. Conidia subfusoid, 22 x 5-7.5 microns, with 5-6 cells and the middle ones with 3 setae up to 17 microns long.

Phyllachora balansae Speg. — Leaf spot

Reported in Dominican Republic on Swietenia humilis.

Phyllachora swieteniae Petr. & Cif. — Tar spot

Reported in Dominican Republic and United States (Florida). Numerous black fruiting bodies in groups distort and disfigure the leaves.

Thread blight (cause unknown) — Cobweb disease

Reported in Java on 22-year-old Swietenia mahagoni. Attacks branches on underside. Affected parts covered with strong white mycelial cord which occasionally divides to form a network increasing in density towards top. Mycelial cord attacks petioles

and undersurface of leaves which wither and turn brown. Mycelium consists of thin-walled septate hyphae with clamp connections, swollen anchor cells, and swollen hyphal tips. No fruiting bodies known.

SYSTEMIC DISEASES

Virus (?)

Reported in Trinidad on Swietenia macrophylla. The cause is unknown but superficially appears to be a virus. Cankers on stem and branches make infected trees worthless.

Dieback (cause unknown)

Reported in Puerto Rico on Swietenia mahagoni. Branches die from tips downward, giving trees a "stag-headed" appearance. Resembles drought injury in appearance but occurs in typical rain forest environment.

WOOD-ROTTING FUNGI

The following fungi have been reported as causing decay of mahogany wood in service. They may or may not cause decay of the wood in living trees.

Fungus	Reported from
Coniophora cerebella Pers.	Russia
Daedalea quercina Fr.	U.S.A.
Fomes durissimus Lloyd	Pakistan
Fomes linteus (Berk. & Curt.) Cke.	Texas (USA) to Brazil
Fomes rimosus (Berk.) Fr.	Barbados
Fomes swieteniae (Murr.) Rick	U.S.A.
Ganoderma lucidum (Fr.) Karst.	India
Lenzites trabea Fr.	U.S.A.
Merulius lacrymans Fr.	Russia
Polyporus gilvus (Schw.) Fr. f. licnoides (Mont.) Lloyd	India
Polyporus sanguineus Fr.	Europe, U.S.A.
Polyporus versicolor Fr.	Europe, U.S.A.
Polyporus zonalis Berk.	Philippines
Poria oleraceae Dav. & Lom.	U.S.A.
Poria xantha (Fr.) Cke.	U.S.A.
Schizophyllum commune Fr.	Phillipines
Scortechinia acanthostroma (Mont.) Sacc. & Berl.	U.S.A.
Trametes corrugata (Pers.) Bres.	Peru
Trametes serialis Fr.	U.S.A.

DISEASES OF TECTONA GRANDIS[1]

by

B. K. Bakshi[2]

Teak has a worldwide reputation for its timber which is durable, seasons well, does not warp or split and is extensively used for constructional work. It is indigenous throughout the greater part of Burma, South India, Thailand and Java. Teak thrives best in moist, warm, tropical climates where frost is absent, normal rainfall is 50-150 inches per year and soil is well drained, deep alluvial. Because of the quality timber, teak is widely planted outside its natural range of distribution. The species is deciduous - leaf fall occurs during winter and new leaves appear in the spring. The species is a light demander and does not tolerate suppression at any stage of its growth. It is sensitive to frost and drought but can resist the effects of fire. It coppices well. Teak regenerates naturally and is also planted. Plantations are established by direct sowing or by outplanting seedling stock raised in the nursery. Tending operations in a teak plantation consist of weeding, cleaning to remove inferior tree species which tend to suppress teak, and thinning, which should start at an age of 10-12 years and continue frequently but lightly up to an age of about 25-30 years, after which thinning is heavy and at gradually increasing intervals.

The silvicultural practices under which natural teak forests are worked consist of coppice with standard, selection felling and clear felling with natural reproduction by seed or coppice, which is supplemented by artificial reproduction. The role of fire is important. Protection from fire improves natural regeneration in dry forests but, if practiced in the moister type of forests, it encourages growth of inferior species, bamboo and other undergrowth, which retard regeneration. Continued fire protection may encourage evergreen species to become established in deciduous teak forests.

Reports on the diseases in teak are many, though in some cases, they are not diagnosed. For example, reports from Burma (personal communication, 1959) indicate that teak was dying in many

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1 For distribution at the FAO/IUFRO Symposium on Internationally Dangerous Forest Diseases and Insects, Oxford, England, July 1964

2 Forest Research Institute, Dehra Dun, India

plantations from time to time and fungi were suspected to be responsible in most cases. It is reported from the Philippines (personal communication, 1959) that an unidentified root disease of teak in plantations may become very dangerous. The cause of large scale dying of teak in a coppice teak crop about 25 years old in Bombay (India) during 1954-55 was undetermined. Mortality in teak in plantations in Sudan is causing great concern and the cause is yet unknown. Because of large scale attempts to plant teak, in some cases outside its natural range of distribution, it is important that its diseases are studied, so that they do not become a limiting factor in raising this valuable timber species.

SEEDLING DISEASES

Pseudomonas solanacearum E.F. Sm. — Vascular wilt

The disease is reported in Malaya and Sumatra. Causes vascular disease of many economically important plants, ranging from herbs to large timber trees. Symptoms are dwarfing, sudden wilting, shriveling of foliage and brown stain of vascular bundles. Distribution world-wide. Host range includes plants of 17 families of which Solanaceae are most susceptible. Also causes slime disease of teak in Sumatra and Java, characterized by sudden wilting and brown discolouration of young trees in plantations.

Pseudomonas tectonae Rolden and Andres — Bacterial wilt

First observed in 1948 in nursery of the Magat Reforestation Project, Bagabag, Nueva Vizcaya, Philippines and by 1949 threatened to disrupt the entire project. Initial symptoms are gradual loss of turgor or sudden acute wilting early in the day, particularly during clear, hot, sunny weather. The disease becomes more pronounced on each successive day until the plants collapse and die. The bacterium enters xylem vessels of roots and stems. The bacterium is a moderately motile rod with ends rounded and a single polar flagellum. It is non-spore forming, slightly capsulate, aerobic, gram negative and non-acid fast, and measures 1.65-4.33 x 0.45 - 1.28 microns. Thermal death point is between 52°C and 53°C and optimum temperature for growth between 25°C to 30°C.

Control consists of destroying diseased or suspected plants, avoiding root injury, and planting infested nursery soil continuously under teak seedlings with a resistant species for some time or in urgent cases setting out a new nursery on unbroken forest soil and avoiding the introduction of contaminated soil.

ROOT DISEASES

<u>Armillaria mellea</u> (Fr.) Quél. — Shoestring root rot

Teak attacked by root rot in South Celebes (Dutch East Indies), probably due to <u>A. mellea</u>.

<u>Fomes lamaoensis</u> (Murr.) Sacc. & Trott. — Brown root rot

Recorded on teak in East Indies. Fruit bodies woody, sessile, thin, flat, medium sized, surface zonate, horny, incrusted. Causes honey-combed rot.

<u>Fomes noxius</u> Corner — Basal root rot

Reported as causing basal root rot in teak in plantations in Java and Tanganyika (Africa).

<u>Helicobasidium compactum</u> Boed. — Root rot

Reported in East Indies. Causes root rot accompanied by decline of the foliage, production of sprouts and death. Control measures include uprooting and burning of diseased material, cleaning the soil surrounding the trees and application of carbolineum-lime washes.

<u>Helicobasidium</u> (?) sp. — Root rot

Reported in plantations in South Sudan, usually in plants up to 12 years, occasionally up to 25 years. The disease appears on individual trees and gradually spreads to neighbouring ones, so that affected trees occur in groups. The diseased tree dies from top downwards, leaves turn brown and shed prematurely and the whole tree dies. The bark near root collar becomes dark and soft and develops underneath a white fungal mycelium, forming papery layers in succession. Bark and sapwood disintegrate and become friable. Root system is affected. The spread arrested when dead and dying trees are removed, possibly due to admission of sunlight.

<u>Polyporus zonalis</u> Berk. — Root rot

Recorded in 30-year old teak plantations, Dehra Dun, India. Attacks roots and bases of trees. Recorded on other hosts like <u>Sapindus emarginatus</u>, <u>Bauhinia purpurea</u>, <u>Syzygium cumini</u>, <u>Ficus bengalensis</u> and <u>Hevea braziliensis</u>. Sporophores sessile, with white to pink zoned upper surface; white context, pore tubes and hymenial surface, globose basidiospores and incrusted cystidia and ocanthophyses. Causes white pocket rot in the heartwood.

<u>Xylaria thwaitesii</u> Cke. — Root rot

Recorded on teak in East Indies and dead roots of young teak in Java plantations. Serious disease of <u>Hevea</u> where it forms black, flat bands or patches on roots. Diseased trees die.

Causes a brownish-grey, moist rot, hard at the centre but with soft decay on the outside.

Cause unknown — Root rot

Reported in young plantations, East Pakistan. Early defoliation and girdling in the root results in death of trees in patches. Spread facilitated in pure stands. Control suggested in planting mixed stands, trenching diseased trees and removal of diseased trees as foci for further spread of the disease.

Cause unknown — Mortality

Reported on teak 2.5 - 60 cms d.b.h. in plantation at Los Banos, Philippines, where 20 percent of 187 trees were affected. Appears to start at the region of the root collar affecting the bark inward to the cambium layer and spreading simultaneously upward to the top and branches and downwards to the roots. Trees severely attacked die or are susceptible to windthrow.

STEM DISEASES

Corticium salmonicolor B. & Br. — Pink disease

Reported from several places in Java, Sumatra and India. Attacks trees of all ages. Infection of teak up to 15-20 percent in west and central Java and 55 percent of the 3,100 trees in an old teak forest of Sarandan. There are a number of other susceptible hosts which include *Burea monosperma*, *Swietenia mahagoni*, *Schleichera oleosa*, *Tamarindus indica*, *Acacia leicophloea*, *Cassia siamea*, *Leucaena gluca*, *Pithecolobium dulce*, *Hevea braziliensis* and *Ficus* sp. On these other hosts, the pathogen is widely distributed in Africa, Asia, Australia, and North and South America.

Very young branches rapidly killed, the foliage wilting and turning black. The bark is entirely destroyed if the lesions penetrate to the wood. In old trees, large holes occur in stem and they penetrate deeply in the wood.

Infection occurs on healthy branches through lenticels or wounds and produces white pustules, composed of intertwined mycelium on the bark representing sterile stage. From the pustules white, glistening mycelium develops which turns pink and powdery and eventually into brittle incrustation representing the *Corticium* stage. Basidiospores globular, 6 - 4.5 microns in diameter. Waxy, orange imperfect stage, *Necator decretus*, found commonly on *Hevea* rubber and other hosts, not found on teak.

☆ U.S. GOVERNMENT PRINTING OFFICE : 1964 O—700-464 (29)